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CITY COUNTY STATE

FEBRUARY 5, 1921

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PUBLIC WORKS.

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Non-rigid Bases For Pavements

By Prevost Hubbard

In an article entitled "Flexible Pavement Bases" published in the January 29th issue of PUBLIC WORKS we gave extracts from and abstracts of parts of a paper presented before the Engineers' Club of Philadelphia a few weeks ago by Prevost Hubbard. This paper described some tests made by Mr. Hubbard on rigid and non-rigid bases, but only incidentally discussed the comparative advantages of the two. At our request Mr. Hubbard has prepared for this issue the following article in which he states briefly the advantages of asphaltic bases for pavements from his point of view. Mr. Hubbard was for several years chief of the Division of Road Material Tests and Research in the Office of Public Roads of the United States Department of Agriculture, and is the author of "Laboratory Manual of Bituminous Materials, for the Use of Students in Highway Engineering." Recently he has become associated with the Asphalt Association as chemical engineer.

There are two basic types of highway design, the rigid and the flexible. The first is represented by such pavements as Portland cement concrete and monolithic brick, and the second by the various bituminous pavements such as asphaltic concrete and sheet asphalt. There is also a composite or semi-rigid type represented by the Portland cement concrete base with a bituminous wearing course. A pavement of the fully flexible type has its base as well as its surface flexible, or is of one uniform flexible material throughout, as in the case of asphaltic concrete.

SHEET ASPHALT ON FLEXIBLE BASE IN VISALIA, CALIFORNIA
A 1-inch sheet asphalt surface on a 6-inch asphaltic concrete base, laid in 1894. The city engineer reported in 1920 that nothing had been spent for maintenance

ASPHALTIC CONCRETE BASE IN ALAMEDA
A 2-inch asphaltic concrete surface on a 3-inch asphaltic concrete base, laid in 1914. Present condition, excellent. Maintenance, none. The painted lines indicated parking spaces.

An asphalt base consists of mineral aggregate bound together with asphalt cement and forming a layer not less than 2½ inches thick. It should not be confused with asphalt binder, which is a relatively thin intermediate course placed between a sheet asphalt wearing course and a foundation proper, and is altogether omitted when an asphalt base is used, being then unnecessary.

There are two types of asphalt base known as asphalt macadam or the penetration type, and asphaltic concrete or the mixed type. The asphalt macadam base is constructed in much the same manner as an asphalt macadam pavement, but the seal coat and use of small stone to fill surface voids should be dispensed with, except that when a sheet asphalt or fine graded aggregate asphaltic concrete surface course is to be laid upon it, the small stone should be used on the top of the base. The base is usually laid in one or more courses, each varying from 2½ to 4 inches in thickness.

The mixed type of base consists of a coarse graded aggregate asphaltic concrete, laid and compacted while hot in one or more courses each 2 to 4 inches thick in exactly the same manner as the asphaltic concrete pavement. As it is neither necessary nor desirable to produce an extremely close surface, there is no need to use mineral filler in its preparation.

Bituminous bases have been laid for more than 40 years, and have given continuously satisfactory service for 20 years or more in Washington, D. C., Chicago, Omaha, Pittsburgh, Buffalo, Denver and other cities. More recently the use of the asphalt base has become more widespread, especially in the west. The state of Oregon contains nearly 7,000,000 square yards of asphaltic base and even more has been laid in California, where Sacramento has laid more than 300,000 square yards, Fresno more than 255,000, and several other cities have laid more than 100,000 each.

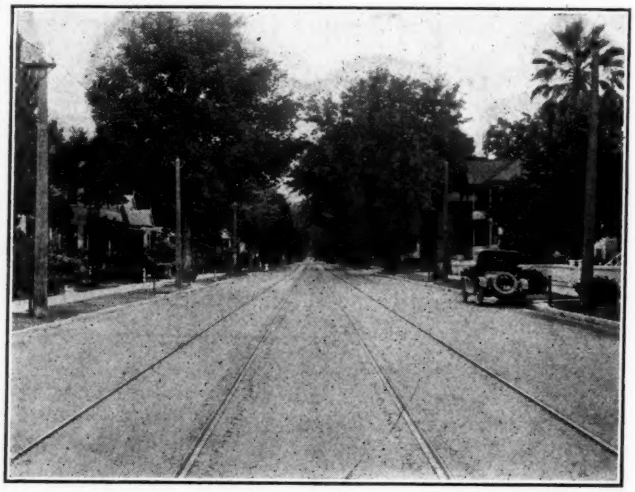
ADVANTAGES OF ASPHALT BASE

While a rigid type of foundation relies upon bridging action for support over small areas of compressible subgrade, the asphaltic base, because of its flexibility, maintains contact with the subgrade and thus utilizes its supporting value to the fullest extent. Under many conditions which would produce cracking in a rigid foundation, the slight yield of an asphalt foundation will maintain the pavement intact.

Experiments conducted by the Bureau of Public Roads (described in PUBLIC WORKS several months ago) have shown that impact from heavy traffic is one of the most destructive agencies to which modern highways are subjected. Any shock-absorbing element in a pavement reduces the destructive tendency of impact to both pavement and vehicles. An asphalt base is far more shock-absorbent than a rigid base, and in this respect possesses so decided an advantage over the latter that it may under many conditions be laid with safety to a less thickness than would be required for a rigid base.

Where the wearing course is of asphalt, the asphalt base offers additional advantages. There is a firm bond between wearing course and base, since the asphaltic base and asphaltic top knit together to produce an integral structure and materially reduce all tendency of the wearing course to shove under traffic at the point of contact between base and wearing course.

In the rigid type of base there exists the same inherent tendency to crack as in the rigid type of road, and when such cracks form they are more than apt to be carried through the asphalt wearing course, while there is little tendency for an asphalt top to crack when laid on a flexible base.



FLEXIBLE BASE ON STREET WITH TRACKS IN SACRAMENTO
A 1-½inch asphaltic concrete surface on a 3½-inch asphaltic concrete base, laid in 1915. Present condition, excellent; cost for maintenance, none.

Because a rigid base is not shock-absorbent, it acts as an anvil upon which the asphalt wearing course is subjected to a much more severe strain from the impact of traffic than is the case where the base itself is shock-absorbent in character.

Asphalt is used extensively in the water-proofing and roofing industries and a dense asphaltic concrete base with asphaltic wearing course produces a structure water-proof throughout and one therefore not subjected to internal stress due to absorption of water or to distintegration by frost action. On the other hand, the usual Portland cement concrete base is not water-proof but actually absorbs moisture from the subgrade by capillarity, which moisture tends to expand the concrete and subject it to internal stress. It also frequently maintains a film of moisture between it and the asphalt wearing course which is a source of weakness and may greatly accelerate disintegration.

An asphaltic base permits of several economies in construction. No type of foundation can be adapted more readily to the utilization of available local material. When laid in conjunction with an asphalt top it requires only one organization and equipment to be maintained by the contractor, while, as stated by a prominent contractor, "Cement concrete requires additional equipment and a different organization and the work is necessarily slower in progress."

Where asphalt base is used, the pavement is ready to receive the wearing course immediately, and entire sections of the pavement may be laid and opened to traffic within a period of 24 hours; while a pavement of concrete or with a concrete base should be closed to traffic for at least 10 days. This is often an important consideration in both original construction and repairs.

The maintenance cost on asphalt pavements has been as a rule exceedingly low. Examples can be cited of such bases which have given 10 to 20 years' service with no maintenance, notwithstanding an increase in volume and weight of traffic which could not be forseen when the pavements were constructed. In 1894 the city of Visalia, Cal., constructed three blocks of asphalt base pavement on Main Street, this being a 6-inch base with a 1-inch sheet asphalt wearing course. In June, 1920, city engineer L. H. Gadsby reported that "Nothing has been expended for maintenance on this pavement and it is in excellent condition today. We have no doubt that this pavement is good for many future years of service in spite of the tremendous increase of traffic in volume and especially in weight." The same city built 10 years ago a 4-inch asphaltic concrete base without any wearing course, which has successfully carried heavy traffic from trucks and trailers piled high with fruit. In 1916 Kings County, Cal., constructed approximately 103 miles of asphaltic concrete pavement consisting of 2½ inch base and 1½ inch wearing course. The traffic is considered heavy, trucks weighing 10 to 14 tons traversing certain sections, but after 4 years of service all but one mile was in excellent condition and County Engineer Roy Maye reported last year a total expenditure for maintenance of this pavement of but $1,599.78, most of which expense had been incurred on one mile over a stretch of poor foundation.

THE ILLINOIS STANDARD

In certain localities an attempt has been made to standardize the design of all pavements for heavy traffic upon the basis of a rigid slab or beam because of its bridging value. Such pavements have been adopted as standard by Illinois, Clifford Older, chief highway engineer of that state, stating that "A standard concrete slab 7 inches thick at the side and 8 inches at the center for 16 to 18-foot widths has . . . been adopted by the state of Illinois as the basis for all its rigid surfacng." He admitted that it was a matter of opinion as to how much weight could be given to the transverse strength and cushioning effect of a bituminous wearing course and dismissed the subject by stating that "It has been decided for the sake of simplicity to allow the equivalent of 1 inch of concrete for both the 2-inch and 3-inch wearing surface."

This would require a base 7 inches thick at the center for sheet asphalt or other bituminous wearing surfaces, which is one inch thicker than the bases that for years have given satisfactory service in hundreds of cities. In addition, he requires a mixture of 1:2:3½ concrete, while 1:3:6 concrete has been in common and satisfactory use for city traffic for many years.

In certain quarters Mr. Older's conclusions have been accepted apparently without question, but the long service history and present condition under

ASPHALTIC CONCRETE ON NON-RIGID BASE IN HAYWARD, CALIFORNIA
Constructed in 1908, with 1½-inch asphaltic concrete surface on 3-inch asphaltic concrete base. The present condition is good, although nothing has been spent for maintenance.

heavy traffic of 6-inch 1:3:6 Portland cement concrete base, with a wearing course of 2 to 3 inches of asphaltic concrete or sheet asphalt, at least make these conclusions questionable if they do not absolutely disprove them.

ABSOLUTE RIGIDITY SELDOM NECESSARY—NEVER DESIRABLE

While the rigid type of foundation has certain valuable characteristics inherent to its rigidity, it also possesses some objectionable features which do not occur in the flexble type of foundaton. The service history of old macadam and telford roads which have been successfully utilized as foundations for asphalt pavements is positive proof that absolute rigidity in the foundation is not essential, provided adequate support is furnished by the subgrade. While the stability of a newly constructed broken stone foundation seldom if ever equals that of an old consolidated broken stone road, the use of asphalt in its construction will produce an even greater degree of stability, as is well known.

No practicable design of highway permits the assumption of more than a temporary bridging action over appreciable areas of a weak subgrade. In fact, it is now generally admitted that very careful preparation of the subgrade is necessary to uniformly support the all-rigid types of pavement. With some amount of care in subgrade preparation there is probably less chance of a failure in a partly flexible foundation. The failure of a rigid base to successfully bridge over large areas of poor foundation, even when covered with an asphaltic wearing course, was illustrated by the utter destruction of such a pavement over a sub-base weakened by frost action which was described in Public Works for August 14, 1920. (See page 134.)

The importance of impact in the destruction of highways has been referred to. In order to compare the relative resistance of rigid concrete base and asphaltic base, experiments under impact are being conducted by the writer. Some of these tests were described in a paper which was presented in abstract in the January 29th issue of Public Works. It will therefore suffice simply to state in this article that, while the tests have not yet been carried to the point where definite comparisons can be made on all designs and types, a sufficient number of results have been secured to indicate general tendencies. These show the following: (1) Compressed asphaltic paving mixtures developed very decided slab strength as measured by their resistance to impact; (2) in the semi-rigid type of construction the asphaltic wearing course greatly increases the resistance of the structure to impact.

IMPORTANCE OF SUBGRADE

The asphalt base has proved much more popular in the west than it has so far in the east, but it is believed that, once given a fair trial in localities where it has not yet been used, its general adoption for many highways which would otherwise be constructed with a more expensive rigid base will follow. Conditions in California were especially favorable to this kind of base in that the soil and climatic conditions produced natural subgrades with high supporting value. Similarly favorable conditions can be obtained in other localities by proper drainage, compaction and in some cases special preparation and modifications of the existing subgrade. Such favorable condition of subgrade having been obtained, there can be no question that flexible bases will prove as satisfactory elsewhere as they have been for many years on the Pacific Coast, where relatively thin asphaltic pavements have for years successfully withstood the punishments of a heavy traffic, while under the same conditions the rigid type of pavement has been badly injured or destroyed. In many cases it will cost less to drain and otherwise improve the subgrade than to provide the additional thickness of base required, whether this be of a rigid or non-rigid type; and given a good subgrade, the flexible base may be expected to repeat anywhere the success which it has had in the western states.

Much can be done toward keeping a subgrade dry by proper drainage, but some soils are so persistently retentive of moisture once absorbed that it is impossible to remove it with sufficient rapidity by any ordinary system of drains. Such a subgrade may frequently be greatly improved at relatively low cost by mixing sand with it, forming a sand-clay road. Such a mixture will retain less moisture than clay and when moist will possess a much higher supporting value than moist clay. Similarly, sands which are unstable when dry may have their supporting value increased by thoroughly mixing clay with them. Other soils of light, pulverant character which fail to compact satisfactorily may be hardened by a dressing of gravel, slag or broken stone. In other cases it may be necessary to distribute the load over a larger area by laying a sub-base course of gravel, slag or broken stone. Western states and cities have found a 4-inch compacted sub-base adequate to care for heavy traffic in trunk line routes. An old macadam, telford or gravel road makes an excellent sub-base when it is available.

The above suggestions for the improvement of sub-base are given merely to indicate that it is practicable and frequently inexpensive to produce a sub-base as favorable to a flexible base pavement as is the soil naturally found in the far west where the greatest experience and success have been had with this type of base.

FOR NON-BITUMINOUS WEARING COURSES

In conclusion, it may be suggested that the asphalt base is desirable not only for bituminous wearing surfaces, but also for brick and block pavements. A Portland cement grout filler in either brick or block construction produces a rigid pavement which requires a rigid base to maintain its integrity. The National Paving Brick Manufacturers' Association, although a few years ago greatly in favor of the cement grout filler, has during the past year or two recommended the bituminous filler. Asphalt filler for both brick and stone block has among its advantages the prevention of cracks caused by temperature changes, ease of repair, and accessibility to traffic immediately after construction instead of keeping the pavement closed for a week or ten days as is necessary if a grout filler is used. With a bituminous filler, a block pavement of any kind—brick, stone or wood—can secure many of the advantages of a flexible pavement by being placed upon a flexible base.

Absolute rigidity is seldom necessary and is never a desirable characteristic in a pavement structure.

The Illinois Experimental Highway

By Prof. Chas. Carroll Brown*

Of the several groups of pavements constructed to test or demonstrate the effect of variations in paving materials or construction that have been installed and tested during the past few years, that now under construction by the Illinois Division of Highways possesses several unusual features which are worthy of note.

This stretch of two miles can be built and the test completed without its having to carry any regular traffic, after which it will become a regular traffic highway. The sub-grade and other natural conditions throughout the entire route are as nearly uniform in all particulars as could be obtained. Although there are 64 sections, only a few varieties of materials are being tested—in fact, the entire test appears to be chiefly one of concrete as a complete pavement and as a base for brick and asphaltic surfaces, and to be made to determine the best method of constructing concrete pavements and bases.

This description has been written after a personal examination in combination with a collection of official data, by one who needs no introduction to the readers of engineering periodicals.

A test road is being constructed by the Illinois Division of Highways for the purpose of conducting experiments upon concrete roads, and concrete bases with brick and asphaltic concrete wearing surfaces, each constructed with variations in thickness, reinforcement, treatment of wearing surface, etc., so as to add definite information and data to the theoretical and practical knowledge of the wear and failure of highways. The ideas entertained by Clifford Older, the chief engineer of the Illinois Division of Highways, and adopted as a basis for the specifications of the highways of that state are generally known, and presumably a considerable part of these tests will be devoted to trying out certain of Mr. Older's theories, which will be described later on in this article.

GENERAL DESCRIPTION OF ROAD

The pavement is divided into sections 100, 150 or 200 feet long, about 40 per cent of them being concrete pavement and the others being brick pavement with bituminous and grout filler, and asphaltic concrete pavement, both on concrete base, except for eleven sections of brick and asphaltic concrete which are on a macadam base. It is unfortunate that the department has not recognized the great importance and value of bituminous-bound foundations for pavements for such unfavorable conditions as are bound to be found in the subgrade of this test road and that none of the sections have been laid with such foundations. It is not often that conditions so uniform in all respects are found as there are in this length of pavement, especially when the location of the road is considered and the consequent possibility of keeping general traffic off until the traffic test has been completed.

The road runs approximately east and west, paralleling the Wabash railway on the south, about 14 miles west of Springfield. The entire test road is on a new location intended ultimately to replace another road several feet away. Only one existing road is crossed by the experimental road, and this crossing will be paved with 50 feet of standard 8-inch concrete pavement. It will be possible, therefore, to construct the road, test it, and repair or reconstruct any section that may require it, before turning the regular traffic over it.

The conditions as to grade, drainage, character of soil in subgrade, and stability of the same are as nearly uniform as could be secured in any two miles of road. The sub-soil throughout is of brown silt loam—the common clayey soil of the Illinois prairies. Owing to almost entire lack of surface drainage there are considerable areas where it has the appearance of black swamp soil and approximates the waxy characteristics of the soil called gumbo. The grades are undulating, varying from zero for 100 or 200 feet at summits or bottoms of grades to a maximum of 0.4 per cent for even shorter distances, the grades averaging 0.1 per cent. Concrete box culverts are placed at the bottom of each of the two principal synclines, which connect side ditches, but as there seems to be no outlet for these ditches the culverts simply equalize the water level on the two sides of the road. The railroad cuts off surface drainage from the north, while on the south the land slopes partly toward the road and partly from it. Drainage ditches of the road that crosses the test road and those of the two roads at the ends of the test road will probably remove some of the water from these ditches. It is probable, however, that after heavy rains water will stand in the side ditches of the test road for considerable distances until it evaporates or soaks into the comparatively impervious sub-soil. It was intended to test the effect of sub-soil drainage upon the moisture in the subgrade, but difficulty of securing an outlet for the drains prevents this. There are many square miles of Illinois area that approximate more or less closely to these conditions, which are about as unfavorable to road maintenance as could be found, and a pavement that will stand

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traffic on this test road under its worst conditions will stand the same traffic on any road in the state.

After the road has been constructed it is proposed to subject it to artificial truck traffic, gradually increasing the weight of this until it exceeds by about 50 per cent the road limit set by the Illinois highway regulations. It would seem advisable to continue such tests through periods when the subgrade will have its lowest value for supporting paving traffic, that is, when the moisture in the soil is at a maximum. Any differences in the amounts of moisture in the subgrade during the testing periods might easily make material difference in the effects of the loads upon the pavement slabs of the various materials, and mention should be made of any such difference in the bulletin which Mr. Older promises descriptive of the details of the design and construction, plan of loading, and apparatus for and methods of observation.

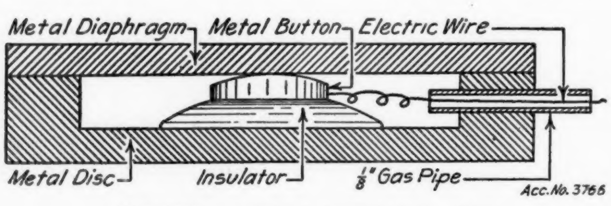
The road is to be built directly by the division of highways, using state equipment and labor employed for this job. E. M. Fleming, acting road engineer, is the engineer in direct charge of construction and is to be highly commended for the careful way in which the details are being carried out. The question of variations in methods of construction is practically eliminated, at least so far as the work already constructed is concerned. It is to be hoped that the winter intermission will not change conditions enough to introduce any uncertainties of this kind.

In the construction of the concrete pavements and bases, Heltzel steel forms were used and, for the concrete pavements, the Parrish road tamper and finisher. The proportions and mix for the different sections of concrete will be described in detail later on.

TESTS TO BE MADE

Pressure cells such as are used by the United States Bureau of Public Roads have been inserted at regular intervals along each edge, the center, and in some places at the quarters of the road, by which the behavior of the subgrade before and during loading can be observed. Special observation pipes have been set on each 25 feet of the length of the road. At each section one observation pipe is set 18 inches from each edge of the pavement and another is set at the center, while in some places additional pipes have been set midway between the sides and the center. At the bottom of each pipe a loose brass disk lies on the subgrade. By means of an inner pipe the disk is forced down when a load deflects the pavement. An Ames dial is used to measure to permanent or temporary depression of the subgrade. The supporting power of the soil may be measured independently by loading the disk. By removing the disk, samples of the sub-soil can be taken as desired in order to determine their moisture content or other characteristics. The top of the outer pipe is flush with the top surface of the concrete and is closed with a plug to keep out the water and dirt, which plug is easily removed.

Observations of the sub-soil action should give data of great value, and the relations of compressibility and moisture content, of load and compression, and possibly of swelling and moisture, will have light thrown upon them proportional to the extent of the observations and the care with which they are made.



GOLDBECK EARTH PRESSURE CELL

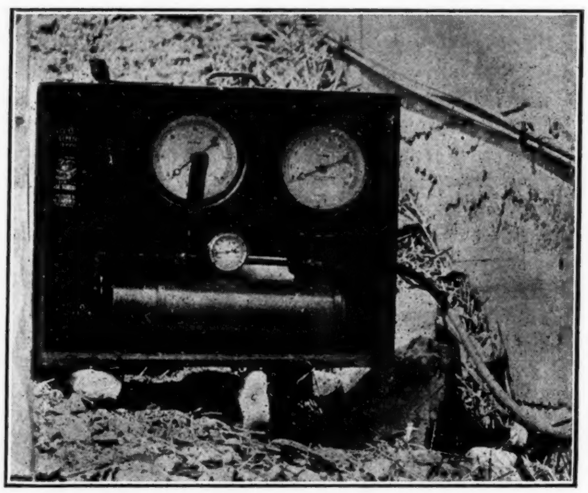
The cell is a hollow metallic disk, one face of which (top face above) is an elastic metal diaphragm. The cell is buried in the earth under the pavement. The earth pressure keeps the diaphragm pressed against the rounded surface of the metal button, thus closing an electric circuit carried by wires to the top of the dam through a small air pipe, as shown. When a measurement is to be made, air is admitted into the hollow of the cell from a compressed air tank, thus balancing the earth pressure, till, just at equilibrium, the diaphragm is forced outward, breaking the electrical contact with the button. The break is indicated by the going out of a small electric indicator lamp in the circuit. The pressure is then read on an air gage connected with the air pipe line.

THE ILLINOIS THEORY OF PAVEMENTS

In a paper by Chief Engineer Older before the recent meeting of the Association of State Highway Officials, he developed the present tentative method of design of rigid pavements used in his department, and gave the reasons therefore so far as they have been definitely determined. He assumes as demonstrated that wear of the surface of rigid pavements on well-constructed rural highways is a negligable factor and that internal stresses due to the expansion of the pavement can be resisted by the pavement material. He acknowledges that no method has yet been devised for preventing the cracks that occur in rigid pavements, but states that if they are properly cared for they affect the rigid slabs between cracks and joints only as they may affect its strength or load-carrying capacity,

The thesis of his paper was the determination of the characteristics of a design which will give slabs or fractions of slabs sufficient strength to carry the loads to which they will be subjected.

He assumes as a demonstrated fact that a concentrated load on the slab at or near its center will have much less effect than one on an edge of the slab, and that one at the intersection of edges, joints or



PRESSURE RECORDING APPARATUS
At right is seen pipe leading to pressure cell

cracks, that is, at a corner of a slab or fraction thereof, will have the greatest effect in breaking the slab. It is therefore necessary to so design the entire slab that the corner will carry the imposed loads.

Some investigations by the Illinois division of highways as well as experiments by the United States Bureau of Public Roads show that clay soils have their supporting capacity greatly reduced in some proportion to the amount of moisture contained in the clay. Much of the soil of the Illinois corn belt is clay that absorbs moisture rapidly and, under the very generally existing conditions of rainfall and lack of drainage, may have its supporting capacity near the surface reduced almost to zero for a considerable part of the year. Under what may be considered ordinary conditions this lack of supporting power may be observed quite frequently. Mr. Older cited an 18-foot pavement laid on a subgrade on which no rain had fallen for 6 weeks, which subgrade, when the pavement was about a month old and following two days of drizzly rain, was found to contain about 17 per cent of moisture under the center of the slab.

He considers it proper, therefore, to assume, for the purpose of making the corners of the slab as strong as the center, that the supporting power of the clay under a corner is or may be zero. The design of the entire slab depends therefore on the design of the corners.

Another assumption is that no economical use of reinforcing steel has yet been devised.

It is proposed to omit bituminous filled expansion joints and to use instead frequent dividing planes with dowel pins or tongue-and-groove joints, so that the erractic transverse cracks may be expected not to open materially. Such a joint has been formed in the experimental pavement by using a strip of horizontally corrugated galvanized metal set in the vertical joint between sections. The same sort of joint is used longitudinally down the center of some of the sections of the experimental pavement.

It is believed that with this sort of a joint a wheel load placed on one side of a joint or crack near a corner may be considered as divided equally between the adjacent corners. With bituminous filled expansion joints or infrequent contraction joints or dividing planes, the wheel load must ail be considered as being carried by one corner, according to Mr. Older.

Observations of vibrations in slabs and especially at corners with loads passing near, indicate that the effect of impact may be considered as offset by subgrade support, and improbability of the maximum wheel load ever being applied at the point causing maximum movement.

With a given load at a slab corner, the natural tendency would be for the slab, acting as a beam supported at one end and free at the other, to bend downward, setting up a tensile stress in the upper part of a cross section taken at an angle of 45 per cent with the two edges of the slab that meet at this corner. The perpendicular distance from the corner to this critical section is unknown, but the length of the critical cross section is twice the perpendicular described. Using the standard formula for the depth of slab in terms of moment of inertia, the unknown disappears in the reduction and the value of the depth of the slab is found to be the square root of the quotient obtained by dividing three times the load on the corner by the allowable tensile stress of the material in the upper part of the slab. If the load is assumed to be divided between two adjacent slabs, the quantity under the radical will be divided by two. In other words, the depth of the slab will be the same throughout, and independent of the distances of the section from the load.

Mr. Older does not consider the shear set up in the slab by the load, but a few moments' consideration will show that it is of importance for only a short distance from the corner and that the load as ordinarily applied to the corner through the bearing of the tire on the slab will probably more than cover the critical section on account of shear.

Instances were cited of breaks made at corners which confirm the judgment exhibited in the above assumption and deductions therefrom. The fiber stress in the concrete will be shown by computation to be about 750 pounds per square inch but is undoubtedly less at or near the corner for the reasons just given. The modulus of rupture of the concrete in one example cited was probably between 500 and 600 pounds per square inch. Only 12 corners were broken out of several hundred in the case under consideration, indicating that the maximum computed stress is seldom or never reached and the ultimate strength of the concrete was seldom reached; owing partly to support to some extent by the subgrade, partly to mutual support of adjacent corners, and to the fact that the truck loads only approach the corners when two trucks turned out to pass each other. Only about 1,500 loads of stone were hauled during the period of investigation, the other loads being negligible in number and weight.

Said Mr. Older: "The further investigation of slab deflections and stresses, the effect of mix, type of wearing surface, etc., on modulus of rupture, the supporting capacity of soils with varying moisture content, the variation of the moisture content and supporting capacity of such soils under pavement slabs at different seasons and with different types of drainage systems, the compression of soils under repeated loads, the possibility of largely controlling the location of longitudinal and transverse cracks by sheet-metal divisions, the mutual support of adjacent slabs afforded by friction of the rough surfaces at cracks, the mutual support of adjacent slabs which may be secured by artificial means at dividing planes, and other items affecting the transverse supporting capacity of pavement slabs is being carried on in connection with a two-mile test road being constructed by the Illinois Highway Department, and at favorable points on old pavements."

By permission of Mr. Older and in company with E. M. Fleming, acting road engineer, who has been in direct charge of the construction of the experimental road on the ground, an inspection of the road was made very recently by the writer. From the data furnished by Mr. Older's permission and found in his paper above referred to, and from observations made personally, the preceding general

description of the road has been prepared and the more detailed description given below. The department will, at a later date, publish detailed accounts of the design, construction and testing of this road. The writer is greatly indebted to the engineers named and to Frank T. Sheets, engineer of design, for furnishing these data and facilities for inspecting the road.

(A detailed description of the methods of constructing the various sections of the test road will be given in a subsequent issue.)

Street Paving in Goldsboro

By W. A. Hardenbergh

Four three-bag batches carried in each five-ton truck. Twenty-two men lay one thousand square yards of concrete base a day.

A short time ago PUBLIC WORKS described a concrete road job in North Carolina where Ford trucks carried one-batch loads to the mixer. In a large street paving contract in Goldsboro, N. C., 5-ton trucks are used to carry four three-bag batches to the mixer engaged in laying the concrete base 5 inches thick. The wearing surface is to be asphalt, and the job involves the laying of about 60,000 square yards of 1½-inch binder and 1½-inch wearing course. All the work is within the city limits. The West Construction Co., of Chattanooga, Tenn., is the contractor, and the J. L. Ludlow Co. are engineers for the city.

The work throughout is typical of present-day construction where man economy prevails. (In this connection it is interesting to note that labor conditions are far different now than when the work was started. Men who, as common laborers, were getting $4 per day early in the fall, are now drawing $2.50 and there are possibilities of another cut.) The equipment on the job, which is being pushed forward rapidly, includes a grading scraper, three 5-ton motor trucks, a paving mixer, a crane for handling and unloading aggregate, an asphalt mixing plant, a roller and some horse-drawn trucks. These latter are being used in hauling the asphalt.

Inasmuch as most of the streets are already fairly well to grade, not much grading was necessary. Hand grading, with the occasional use of scrapers and scraping graders, was the rule. Most of the soil is a kind of sandy loam, which handles well, but clay occurs in the lower sections.

Following grading, the street is rolled and the concrete base is laid. This is in accordance with the usual North Carolina state practice, the base being 5 inches thick, of a 1:3:5 mix. Multi-Foote paving mixer (caterpillar tread) is used, turning out three-bag batches. The rate of progress has been very satisfactory, and in places where continuous work is possible, 50 to 60 truck-loads of aggregate are used per day. Each truck-load contains 4 three-bag batches, which means that as much as 1,000 square yards of base are laid in a day under best conditions.

The mixer gang is small. It is composed of the engineer, the fireman, two sub-grade men, three concrete spreaders, and two finishers, a total of nine men. Aggregate, with the cement dumped on top, is brought, as already stated, in motor trucks and the ready proportioned batches are dumped into the mixer scoop.

Three motor trucks are used, all 5-ton. Two are Macks, which are owned by the contractor, and the other is a Federal, which is rented by the hour, as needed. All have power dump and metal bodies, which are divided by hinged metal partitions into four compartments, each compartment being large enough to contain one batch. The truck is backed up to the mixer scoop, the body raised to dumping position, and the gate to the rear compartment loosened. This allows the first batch to slide into the scoop. The truck is then moved forward about a foot so that the mixer scoop can be raised. After the mixer has been charged and the scoop again lowered, the truck is once more backed into position for dumping and the next partition raised, allowing the second compartment to be dumped. This process is repeated, the truck moving forward and backward, until all four compartments have been emptied.

It will be noted that two men at the mixer are assigned to sub-grade work. The trucks are all equipped with solid tires, the Macks having dual rear tires. All of the trucks when loaded cut rather deeply into the subgrade, and the two men are kept busy repairing these cuts, filling, spreading gravel where needed, etc. Smaller trucks, of two or three tons, with pneumatic tires would be a real improvement from this point of view, for even with the precautions observed, some troubles have been encountered where the soil is not well drained, or where the subgrade is soft.

The trucks are loaded with sand, stone and cement at stock piles. An Erie crane, equipped with a 21-foot clam-shell bucket handles the aggregate, unloads cars, etc. Each of the four compartments on every truck is marked to indicate the height to which it is to be filled with stone, it is then filled level full with sand. On top is emptied three bags (for each comparment) of Portland cement. Four men, who assist in leveling the loads and in getting the right amount of sand and stone in each compartment, a foreman and checker, the fireman and the crane engineer are assigned to this work, with two additional men to handle the cement.

Sixty truck-loads is assumed as the proper amount of work for a ten-hour day. This allows about ten minutes for filling, loading, getting cement, and getting out. As a matter of fact usually half this time is sufficient, but the three trucks are now working the mixer at capacity. The crane also is used to unload sand and stone, which are shipped in. If allowed to work uninterrupted, twenty to thirty minutes are sufficient to unload the average car. Large stock-piles are maintained.

This arrangement shows nine men and a foreman at the mixer, eight men and a foreman at the stock-piles, and three truck drivers as the entire mixing, hauling, and laying gang.

The laying of the sheet asphalt has been started only recently. The "hot-stuff" is being hauled in

horse-drawn trucks, as all hauls are short, most of them being less than half a mile.

The asphalt plant used is one manufactured by the One-Fire Asphalt Plant Co., of Chattanooga, Tenn. As its name indicates, the plant operates with only one fire for power, drying, heating, etc. This plant was described recently in PUBLIC WORKS.

The binder course is composed of 75 per cent stone and 25 per cent sand, with about 7½ per cent of Texas asphaltic cement. The surfacing mixture is composed of 30 per cent to 35 per cent of material passing an 80 screen, 50 per cent passing a 40 screen and the balance a 10 screen. The asphaltic cement content is about 10½ to 11 per cent.

Reinforcing Concrete Pavement

The function of reinforcing is described by H. Eltinge Breed as to "preserve the integrity of the pavement and prolong its life." It lessens cracking and renders less injurious the cracks that occur. It also takes stress and lessens fatigue.

The use of reinforcement in concrete pavements has been increasing for several years past. Of the pavements laid during 1920 in several hundred cities as reported to PUBLIC WORKS in January, 1921, about 35 per cent of the concrete pavements included were furnished with reinforcement, some details of which are given elsewhere in this issue.

The function of steel reinforcement is described in a recent discussion by H. Eltinge Breed, consulting highway engineer, as being to "preserve the integrity of the pavement and prolong its life." The following extracts and abstracts from Mr. Breed's discussion give his reasons for advocating reinforcing.

"Steel reinforcing in concrete pavement tends to lessen cracking in the pavement, to render more innocuous those cracks that occur, to prolong the life of the pavement by relieving the fatigue due to tensile stresses, and to justify its cost by increasing the service of the road, decreasing its maintenance, sometimes offsetting the necessity for additional depth of concrete."

CRACKS IN PAVEMENT

"The defect of the concrete pavement today is the cracks that appear upon its surface. If we can prevent those, we shall increase greatly the desirability of the concrete road. . . . Cracks weaken the integrity of the pavement in which they appear, and in the effort toward improvement, we want to eliminate them."

"While only a few cracks appear during the first year after a pavement is built, more develop during the second, and still more during the third, unless the pavement is reinforced. Of the truth of this statement, New York State Highway No. 5,314 is a good example. It was built in 1914 and a crack survey of it was made in April, 1915, 1916 and 1917. In two representative miles there were 1,479 linear feet of cracks in 1915; 3,210 in 1916; and 6,116 in 1917. . . . Five hundred miles of concrete pavement were laid in New York State up to 1919. Seventy-five miles had reinforcement varying from 22 to 25 pounds and from 22 to 30 pounds in weight. In some cases this weight of metal was doubled over bad soil conditions. The sections reinforced are in better condition today, under the same condition of soil, aggregates, etc., than the plain sections are. It is noticeable that with an increased amount of metal there is a decrease in the number of cracks and a much better condition of the paving surface, i.e., freedom from cracks, spalling, etc."

"Cracks are due, as far as we know, to these causes; poor workmanship or poor materials, either of which is intolerable; contraction due to variations in temperature and moisture content; settlement of the subgrade; overloading and impact. Settlement is caused by frost action, by consolidation of the subgrade and by volume changes in the subgrade.

"The first of these causes we can and must prevent; the others we must offset. The most effective means of offsetting them that we have yet discovered is, I believe, the use of steel reinforcement.

"The longitudinal crack is the more serious because, being along the axis of the road, it may catch the wheels of traffic like a track and carry them along its length. The traffic, of course, chips off and wears down the edges and a gash results, which requires maintenance.

"Transverse cracks tend to develop unevenness, one side becoming depressed. Traffic bumps over the ridge, and the resulting impact crumbles the edges and starts spalling."

TENSILE STRESSES

Mr. Breed quotes the familiar impact tests of the Bureau of Roads, showing that a truck may impose an impact of 20,000 pounds if falling from a height of ¼ inch, which may amount to 43,000 pounds if the fall be 3 inches.

"To build roads to withstand such impact as this last would be financially ruinous. What we can and must do is to build roads of such smoothness that there will be no intensification of the impact pressure." Wear due to accidental cracking may be eliminated by using every known precaution to prevent cracking, and, when it does occur, by holding both sides level so as to minimize impact. "To

hold the edges level and prevent the spreading of cracks where they appear is one function of steel reinforcement."

Mr. Breed believes that "impairment of a concrete pavement is due not so much to immediate shocks from above as to cumulative fatigue generated by intermittent tensile stresses. Another function of steel reinforcement is to take these stresses, lessen fatigue and thereby prolong the life of the pavement." That it serves this purpose has not yet been proved by definite, indisputable scientific data, but Mr. Breed believes that it is indicated by observations of roads in actual service.

"If a highway slab were reinforced heavily enough to take its loading in the same manner as the slab design of a building, the cost would be excessive. This is not necessary. In building work, failure is often disastrous, but on a highway it may be cheaper to allow one slab to fail and be rebuilt adequately to the poorer foundation, than uniformly to reinforce the whole roadway in accordance with the worst condition found. . . . "The analogy between the use of steel reinforcing for structural work and for highways will not hold, but the writer believes that steel will be a factor in helping us build better roads. With the proper use of the right amount of reinforcing steel, pavements can be built to withstand the increased traffic that will be put upon them."

AMOUNT OF REINFORCEMENT

Apparently no formula or definite theory has been developed for calculating the scientifically correct amount of reinforcement to place in a road. "On account of the fact that transverse cracks are not as dangerous as longitudinal cracks and as the latter are the ones to be eliminated if possible on account of the destructive effect of traffic running along them, it would seem wise to take a metal that has a ratio of from 1 lengthwise to from 3½ to 5 across the pavement. Many of the standard styles made now have about this ratio and the writer believes it gives the best results. In city work, however, where transverse cracks are more detrimental, the ratio should be from 2½ to 1 crosswise to 1 lengthwise, depending on the length of the slab."

Mr. Breed, at the time of writing this discussion, was constructing at Bennington, Vt., a city pavement in which he was using 40 pounds of metal per hundred square feet on narrow sections on either side of a car track, the concrete being 6 inches deep and the slabs 8 to 9 feet wide, the traffic being medium to light. On the main street of the same city he was using 75 pounds of reinforcement in two layers, 40 pounds to the lower and 35 pounds to the upper, with a width of slab of 14 to 18 feet. Most of this pavement is on a coarse gravel and sand foundation.

In the latest revision of the standard specifications of the American Society for Municipal Improvements which have recently been submitted to letter ballot for adoption by the society, it is recommended that for pavements 20 feet or less in width the reinforcement should be steel fabric of not less than 30 pounds per hundred square feet with the effective area across the pavement four times that along the axis of the pavement and with the spacing of the main members of the fabric between 4 and 6 inches. Where the pavements are wider than 20 feet the weight of reinforcement should be increased one pound for each foot of width of pavement up to 50 feet. It is recommended that the reinforcement be placed two inches below the surface of the pavement and extend to within two inches of the ends and sides of each slab.

Street Work in Port Arthur

Paving costing $162,000 done by city forces at a considerable saving over contract work. Loading chute a great money and time saver.

The city of Port Arthur, Texas, has sold bonds to the amount of $270,000 for improving the streets of the city, and by the end of the fiscal year 1919-20 had spent $162,221 of this amount. Full preparation had been made for the work as soon as the issue was voted, but before the bonds had been actually sold, including equipment and tools costing approximately $10,000, and within 24 hours after receipt of the money from the bonding company the equipment was in operation, and material for which contracts had previously been made was on the way to the city. The estimates of the work were made in the spring of 1919, but up to the time of this report the work (which was done by the city by day labor) had been done at a considerable reduction below the estimated cost, in spite of increased prices, the difference being $25,602 on an expenditure of $162,221.

A considerable part of this saving was made possible by the construction and use of a loading chute at the city dock where the shell used for road surfacing was received by barge and unloaded. In previous years the shell had been unloaded on the bank and reloaded into wagons. By the present method the shell is unloaded from the barge directly into a chute, from which it is loaded by gravity into the wagons. The total cost of the chute was under $300. By its use a 2-cubic-yard wagon can be loaded in two minutes and the price of delivery from the chute is now $.45 a cubic yard as against $.85 when it was loaded from the ground. This saving of $.40 a yard gives a saving of $24,000 on the 60,000 yards that will be used on the work.

It was realized that a shell road was not a permanent improvement nor even a very durable one, but it seemed desirable to secure some kind of improvement in front of all the built-up property and the bonding capacity of the city did not permit any larger expenditure; also, a considerable amount of storm sewer construction was anticipated and it was undesirable to construct a

more expensive pavement until this had been completed. This point is referred to by the city engineer, Clarence E. Ridley, in the concluding paragraphs of his report in which he states that a well-defined plan of permanent street paving should be perfected which would cover a period of ten years, realizing that a shell road has only temporarily lifted the city out of the mud, where it will be again in a few years unless other improvements are made.

Of the cost of the road construction 13½ per cent was drainage, 3½ per cent was grader work, 1½ per cent rolling, 37½ per cent shell, 10 per cent gravel, 25 per cent bridges and culverts, 4½ per cent engineering and 4½ per cent miscellaneous.

With shell roads, maintenance is an important item, since these deteriorate very rapidly when once they are allowed to get into a condition to hold puddles of water after a rain. The city has purchased a combined grader and scarifier and a tractor to draw it and expects to secure more efficient and lasting work at less expense with this equipment.

For cleaning the streets, the city in September, 1919, purchased a street flusher to replace a street broom and a 2½-ton truck and a labor force of 7 men. One man operates the flusher 3 hours each afternoon and 8 hours each night in the business district. Pavements in the residence district are flushed once every 3 days and the business district once every 24 hours. The appearance of the street and the health of the citizens are said to be improved by this system of cleaning, in addition to which the total saving the first 7 months the flusher was in operation was $2,778 over the old method. As the cost of the flusher was $2,152, City Engineer Ridley states that the flusher has already more than saved its cost; $4,000 has been appropriated for street cleaning for the present year as against $9,000 appropriated for this purpose two years ago.

Labor for Public Works

Reports from nearly six hundred city engineers in all parts of the United States show that there is plenty of unskilled labor for carrying out all the public work contemplated by cities for 1921, and that the wages will be very much lower than last year. The reports from all cities are tabulated on the following pages.

During the past month we have secured data and opinions from about six hundred city engineers located in all sections of the country relative to the amount and wages of unskilled labor available for public work. This information was obtained in response to the three questions: "Will there be enough unskilled labor available for public works contemplated for 1921 in your city and vicinity?" "What is the present prevailing price of unskilled labor?" "What do you think it will be next spring?"

There were, of course, a few who hesitated to reply to one or more of these questions and others who expressed some uncertainty, but in the great majority of cases direct and definite replies were received. As the informants were city engineers who are in touch with the public works done in their city and vicinity, it would seem probable that the opinions are at least as valuable and reliable as those which could be obtained from any other class of men. The dependence which can be placed upon these replies is increased by the remarkable unanimity of opinion found in the answers submitted.

ABUNDANCE OF LABOR

Of the replies received and tabulated up to January 20th, 361 expressed an opinion as to whether there would be enough unskilled labor for the public work contemplated for 1921. Of these, 335 stated that there would be, 14 that there probably would be, 3 that there probably would not be, 7 were certain that there would not be, and 2 were doubtful. It certainly had not been anticipated by us that such a very large percentage of our informants would find labor conditions in their vicinities so favorable for public work this year. With such a large proportion of the country provided with abundant labor, it would seem probable that the 7 to 12 places where labor was expected to be scarce could draw upon the rest of the country for any deficiency.

This consensus of opinion of so many men competent to judge would appear to guarantee that public work will not be delayed this year because of scarcity of labor.

WAGES

In the matter of wages there was, as might be expected, great variation in the amounts paid. But here also the unanimity of opinion as to probable reduction of wages for next spring's work is remarkable. The cities replying were grouped according to geographical districts as indicated on the accompanying map, and the average wages now paid was obtained for each group and also the average wages which will probably obtain next spring. Comparing the two averages in each geographical division, the percentage of reduction in wages was calculated and

UNSKILLED LABOR IN UNITED STATES CITIES

Cities and States	Enough unskilled labor for 1921 public works?	Present prevailing wages	Hours per day	Probable wages next spring
Alabama:				
Andalusia	....	$2.00	8	$1.25
Bessemer	Yes	3.00	8	Somewhat less
Montgomery	Yes	2.00-3.00	9	2.50
Arizona:				
Bisbee	Yes	4.50	8	4.50
Tucson	....	3.00-5.00	8	Lower
Arkansas:				
Fort Smith	....	0.40-0.50	..	0.30-0.35
Hot Springs	Yes	2.70	9	Same
Little Rock	Yes	2.50-3.00	9	1.50-2.00
Paragould	No	3.00	10	2.00-2.25
Texarkana	Yes	2.50	9	2.00
California:				
Anaheim	Yes	4.50	8	4.50
Bakersfield	Yes	5.00-6.00	8	5.00-6.00
Calexico	Yes	4.00	8	3.00-3.50
Chico	Yes	3.50	8	4.00
Napa	Yes	5.00	8	4.00
Oroville	Yes	4.00	8	....
Palo Alto	Yes	4.00-6.00	8	4.00-6.00
Porterville	Yes	4.50	9	3.50
San Francisco	....	6.00	8	6.00
Santa Monica	....	5.00	8	....
Vallejo	Yes	6.00	8	6.00
Venice	Yes	4.50	8	3.00
Ventura	Yes	4.00	8	4.00
Colorado:				
Denver	Yes	4.00-5.00	8	4.00-5.00
Greeley	Yes	4.00-5.00	8	Lower
La Junta	Probably	4.00	8	Lower
Leadville	....	4.50	8	4.00
Longmont	Probably	3.60-4.50	9	3.00-4.00
Monte Vista	....	4.00	8	0.35-0.40
Pueblo	....	4.00	8	3.50-4.00
Connecticut:				
Bristol	Yes	5.40	9	0.50
Hartford	Yes	4.25	8	4.00
Manchester	Yes	4.50	9	3.75-4.00
Meriden	Yes	3.50-4.00	8	3.00-3.50
New Britain	....	4.86-5.83	9	4.86
New Canaan	....	5.00	8	4.00
New Haven	Yes	3.60-4.00	9	0.40-0.50
Orange	Yes	6.00	9	5.00
Putnam	Yes	3.50	9	4.00
Southington	Yes	4.50	9	3.00-3.50
Torrington	Yes	5.00	8	4.25
Wallingford	Yes	4.50-5.50	9	4.00-4.50
Delaware:				
Lewes	Yes	4.00	9	3.75
District of Columbia				
Washington	Yes	3.88	8	3.88
Florida				
Fort Myers	Yes	3.00	9	3.00
Orlando	Yes	3.00	10	2.50
Sanford	Yes	3.00	9	2.50
Georgia:				
Albany	Yes	2.00	10	1.50
East Point	Yes	2.50	10	2.00
Idaho:				
Boise	Yes	4.00	8	Lower
Idaho Falls	Yes	5.00	8	4.00-4.50
Malad	....	4.00	8	3.00
Nampa	Yes	5.00	8	4.00
Illinois:				
Benton	....	6.00	8	6.00
Canton	Yes	4.00	8	Same
Carlyle	....	4.00	8	2.50-3.00
Centralia	Yes	0.65	8	0.50-0.60
Champaign	Yes	4.50	9	4.00 10 hours
Chicago	Yes	8.10	9	8.10
Collinsville	Yes	0.75	8	0.75 an hour
Danville	Yes	4.00	8	0.45-0.50
Galena	Yes	4.00	8	....
Galesburg	Yes	0.50	8	0.50
Geneva	....	0.65-0.75	..	0.60-0.65
Joliet	....	6.30	9	7.00 10 hours
Kankakee	Yes	4.50	8	....
Kewanee	Yes	4.80	8	4.00
La Grange	Yes	1.00 per hour	8	0.87½
Marion	....	6.00	8	Same
Morrison	Yes	5.00	9	3.50-4.00
Mt. Carroll	Yes	4.00	8	5.00 10 hours
Murphysboro	Yes	5.20	8	5.20
Ottawa	Yes	0.60	8	0.50
Pana	Yes	4.00	8	4.00
Pekin	Yes	4.80	8	3.60
Streator	....	7.20	8	....
Taylorville	Yes	4.50	8	2.40-2.60
Waukegan	Yes	6.00	8	0.65
Winnetka	Yes (?)	$.75-1.00	8	Same
Indiana:				
Bedford	Yes	4.50	10	4.50
Bicknell	Yes	5.00	10	4.00
Covington	No (?)	3.00-3.50	10	Lower
Crown Point	Yes	4.00	8	3.20
Elkhart	Yes	5.00	9	0.40-0.50
Elwood	Yes	5.00	10	4.50
Fort Wayne	Yes	4.50	10	4.00
Franklin	Yes	5.00	10	3.50-4.00
Gary	Yes	5.00	10	4.00
Greenfield	Yes	4.00	10	0.35
Hartford City	Yes	5.50	10	4.00-4.40

UNSKILLED LABOR IN UNITED STATES CITIES (Continued)

Cities and States	Enough unskilled labor for 1921 public works?	Present prevailing wages	Hours per day	Probable wages next spring
Indiana (Continued)				
Huntington	No	5.00-7.00	10	Not much better
Jennings	Yes	3.50	9	2.50-3.00
Lafayette	Yes	0.45	9	0.35
Linton	Yes	5.00	8	Lower
Noblesville	....	3.50	10	3.00
La Porte	Yes	5.00	9	5.00
Peru	Yes	4.50	10	4.00
Shelbyville	Yes	5.40	9	4.00-4.50
South Bend	Yes	6.00	10	5.00
Terre Haute	Yes	3.20	8	2.50
Iowa:				
Adair	Yes	4.00	10	3.50-4.00
Albia	Yes	4.05	9	0.30
Boone	Yes	4.00	8	4.00
Cedar Falls	Yes	5.00	10	4.00
Cedar Rapids	....	4.80	8	....
Charles City	Yes	5.00	10	4.50
Cherokee	Yes	0.40-0.50	....	No higher
Correctionville	Yes	0.60	....	Same or less
Davenport	Yes	4.05	9	4.05
Denison	....	6.00	10	....
Emmetsburg	Probably	5.00	10	4.00-5.00
Fort Dodge	Yes	0.50-0.60	....	0.40-0.48
Kingsley	Yes	0.60	....	Same or less
Mason City	Yes	5.00	9	4.00
Muscatine	Yes	0.35-0.45	....	0.35-0.40
New Hampton	Yes	4.50	10	3.50
Storm Lake	Yes	5.00	10	5.00
Tabor	Yes	4.00	10	3.50-4.00
Villisca	Yes	4.00	10	3.50-4.00
Waverly	Yes	4.50	10	4.00
Kansas:				
Council Grove	Yes	4.00	8	Lower
Dodge City	Yes	4.00	8	3.20
Fort Scott	Yes	4.00	8	3.20
Hiawatha	....	0.50	8	0.50
Hutchinson	....	0.40-0.50	8	Lower
Independence	Yes	4.00	8	3.50
Manhattan	Yes	4.00	8	2.80-4.00
McPherson	Yes	4.00	8	3.00
Ottawa	Yes	3.50-4.00	8	3.50-4.00
Salina	Yes	4.00	8	3.00-4.00
Winfield	Yes	4.00	8	3.00
Kentucky:				
Ashland	Yes	4.00	9	4.00
Maysville	Yes	0.45-0.50	8-10	Lower
Newport	Yes	3.60	9	3.00
Owensboro	Yes	3.00	10	Same or less
Richmond	Yes	3.50	10	2.50
Louisiana:				
Crowley	Yes	0.25	10	0.20
Kentwood	Yes	2.50	10	....
Minden	....	3.00	8	3.00
South Highlands	Yes	0.30-0.40	9-10	0.20-0.30
Maine:				
Bangor	Yes	4.50	9	3.50-4.00
Gardiner	Probably not	4.00-5.00	8-9	Same
Paris	Yes	3.50	9	3.50
Portland	Yes	5.20	8	5.00
Rockland	Yes	4.00	9	3.00-3.50
Westbrook	Yes	0.50	9	0.40
Maryland:				
Hagerstown	....	3.00	10	3.00
Massachusetts:				
Athol	Yes	4.50	9	4.00
Arlington	Yes	4.50	8	....
Andover	Yes	5.00	8	4.00-4.50
Attleboro	Yes	4.80	8	4.00
Boston	Yes	4.80	8	0.40-0.50
Braintree	Yes	5.00	9	4.00
Brookline	Yes	4.50	8	4.50
Chicopee	Probably	5.00	8	....
Easthampton	Yes	4.00	8	3.20
Haverhill	....	4.75	8	4.75
Lexington	Yes	4.75-5.00	8	Lower
Lee	Yes	4.00	8	4.00
Lynn	Yes	....	8	Same
North Adams	Yes	4.50	8	3.50
Orange	....	4.00	8	Lower
Pittsfield	Yes	5.00	8	4.00
Somerville	....	4.00	8	Lower
Spencer	Yes	4.00	8	....
Wakefield	Yes	4.50	8	....
Waltham	Yes	4.66	8	4.66
Watertown	Yes	5.00	8	5.00
Michigan:				
Alma	Yes	4.00-5.00	10	3.50
Ann Arbor	Yes	5.40	9	4.50
Crystal Falls	Yes	4.23	9	3.50
Detroit	....	4.50	8	3.60
Dowagiac	Yes	4.50	9	4.00
Escanaba	Yes	5.00	8	4.00
Flint	Probably	5.00	10	5.00
Grand Haven	....	0.50	....	....
Howell	Yes	5.40	9	4.00
Hastings	Yes	4.50	10	4.00
Hudson	....	5.50	9	3.50-4.50
Ironwood	Yes	4.25	8	3.50
Jackson	Yes	3.60	8	Not over 4.00
Lansing	....	3.60-5.40	9	....
Muskegon	Yes	4.00	10	4.00
Port Huron	Yes	4.50	9	4.00

UNSKILLED LABOR IN UNITED STATES CITIES (Continued)

Cities and States	Enough unskilled labor for 1921 public works?	Present prevailing wages	Hours per day	Probable wages next spring
Michigan (Continued)				
Sturgis	Yes	4.50	9	3.50-4.00
Three Rivers	Yes	0.60	10	0.55
Wyandotte	....	5.00-6.50	10	6.00
Ypsilanti	Yes	4.50	9	0.50
Minnesota:				
Albert Lea	Yes	5.00	10	5.00
Cloquet	....	0.45	10	0.45
Fairmont	Think so	6.00	10	5.00
Faribault	Doubtful	5.00-5.50	10	3.50-4.00
Farmington	....	0.35	9	0.40-0.45
Hibbing	Yes	5.00	8	5.00
Little Falls	....	4.00	10	3.50
Luverne	Yes	0.60	....	Same or less
Minneapolis	Yes	5.00	8	5.00
Montevideo	Yes	5.00	10	5.00
St. Paul	Yes	5.00	8	3.50
St. Peter	Yes	4.00	10	3.00-4.00
Two Harbors	Yes	0.65	8	0.50
Virginia	Yes	5.00	8	5.00
Winona	Yes	4.00	8	4.00
Mississippi:				
Canton	Yes	2.50	10	1.75
Clarksdale	Yes	2.50	10	Same or less
Laurel	Yes	3.50	10	2.50
Missouri:				
Bethany	Yes	5.00-6.00	10	....
Carthage	..	4.00	9	3.00
Fredericktown	Yes	3.00	10	3.00
Fulton	....	3.20-4.00	8	3.20
St. Louis	Yes	4.50	9	0.35-0.40
Sedalia	Yes	4.00	10	3.50
St. Charles	Yes	4.05	9	3.60
Montana:				
Billings	Yes	5.50	8	4.50
Bozeman	Yes	5.00	8	4.00-4.50
Great Falls	Yes	5.50	....	4.50
Lewiston	Yes	5.00	8	5.00-4.00
Nebraska:				
Columbus	No	6.00	10	Probably higher
Fremont	Yes	5.00	10	4.00
Hastings	Yes	5.00	10	Not over 4.00
Homer	Yes	0.60	..	Same or less
Lincoln	Probably	4.50	10	4.00
Norfolk	Yes	4.00	10	4.00
Omaha	Yes	0.65	..	0.45
Red Cloud	Yes	5.00	10	4.00
Scotts Bluff	Yes	4.50	9	4.00
Nevada:				
Reno	Yes	4.50	8	4.00
New Hampshire:				
Laconia	Probably	4.25	9	4.25
Portsmouth	Yes	4.50	8	4.00
New Jersey:				
Bloomfield	Yes	6.50	9	4.50
Bordentown	Yes	4.50	9	3.60
Clifton	....	4.80	8	3.50-4.00
Garfield	Yes	5.40	9	Lower
Highland Park	Yes	5.40	9	4.50
Madison	Yes	3.00-6.00	9	..
Montclair	Yes	4.50	8	Lower
Newark	Probably	6.00	9	5.00
New Brunswick	Yes	0.55	..	0.50
Passaic	Probably	0.65	..	..
Plainfield	Yes	4.80	8	4.00
Red Bank	....	4.50	9	..
Ridgefield Park	Probably	5.00	8	5.00
Roselle	....	5.00-6.00	9	4.00-5.00
Rutherford	Yes	5.20	8	..
Somerville	Yes	3.20	8	3.20
South Orange	Yes	4.50	8	4.50
Westfield	Yes	6.00	9	4.50
West Hoboken	....	5.50	10	4.00-4.50
West Orange	Yes	5.00	8	4.00
New York:				
Binghamton	Yes	4.00-4.80	8	3.50-4.00
New York—				
Brooklyn Borough	Yes	5.00	8	5.00
Manhattan Borough	Yes	3.00-3.50	8	Same or lower
Buffalo	....	4.40-4.80	8	....
Corning	Yes	0.50	8	0.40
Endicott	Yes	0.45-0.55	8½	0.45-0.50
Geneva	....	5.00	8	4.00
Gloversville	....	4.00	8	3.50-4.00
Haverstraw	....	3.50	8	3.50
Herkimer	Yes	0.50	9	0.50
Hudson Falls	Yes	4.00	8	Less
Lackawanna	Yes	4.00	8	3.50
Little Falls	Yes	5.20	8	4.40
Mamaroneck	....	5.00-7.00	8	....
Niagara Falls	Yes	0.65-0.70	....	0.55-0.60
North Tonawanda	Yes	4.00	8	4.00
Ogdensburg	Yes	3.00	8	No less
Olean	Yes	4.00	8	Lower
Oneida	Yes	5.20	8	4.00
Oneonta	Yes	0.55	....	0.40-0.45
Salamanca	Yes	4.00	8	3.60
Schenectady	Yes	0.70	8	0.50-0.60
Tarrytown	Yes	4.50	8	4.00
Troy	....	4.00	8	....
Watertown	Yes	4.00	8	0.40
Watkins	....	4.25	8	3.25

UNSKILLED LABOR IN UNITED STATES CITIES (Continued)

Cities and States	Enough unskilled labor for 1921 public works?	Present prevailing wages	Hours per day	Probable wages next spring
North Carolina:				
Durham	Yes	3.00	9	Same
Fayetteville	Yes	3.50	10	Not less than 3.00
Greensboro	....	3.50	10	3.00
Monroe	Yes	2.50	10	1.50-2.00
Statesville	Yes	4.00	10	3.00
Washington	Yes	0.30	10	0.25
North Dakota:				
Bismarck	Yes	4.50	9	3.50-4.00
Fargo	Yes	5.00	10	4.00
Valley City	....	0.45	9	0.35-0.40
Ohio:				
Akron	Yes	3.60	9	3.00-3.60
Alliance	Yes	4.00-4.50	8	3.50-4.00
Bellaire	....	4.00	8	4.00
Bucyrus	Yes	4.00	10	0.30-0.35
Chillicothe	Yes	0.40	9-10	0.40
Circleville	No	0.40-0.50	8	0.40
Columbus	Yes	5.00	8	4.00-4.50
Cuyahoga Falls	....	0.50	10	0.50
Delaware	Yes	4.50	10	0.30
East Liverpool	Doubtful	5.00	9	Same
East Youngstown	Yes	3.60	8	3.60
Findlay	Yes	5.00	9	Less
Fremont	Yes	4.50	9	4.50 10 hours
Lakewood	....	5.20	8	4.00
Lancaster	Yes	4.00	8	3.50-4.00
London	Yes	4.00	8	Same
Lorain	Yes	0.55	8	0.50
Marietta	Yes	3.50	8	2.50
Marion	Yes	5.00-6.00	10	5.00-6.00
Norwalk	Yes	4.50	8	....
Oak Hill	....	3.75	8	3.00
Troy	....	5.50	10	0.50
Urbana	....	4.50	10	3.00
Wooster	Yes	4.00	8	3.60
Xenia	Yes	4.00	8	3.00
Zanesville	Yes	4.80	8	4.00 or less
Oklahoma:				
Alta	Yes	4.00	8	3.00 or less
Bartlesville	Yes	4.00	8	
Durant	....	3.20	8	Less
Enid	Yes	5.00	8	5.00
McAllister	Yes	3.25	8	
Oklahoma City	....	4.00	8	3.20
Shawnee	Yes	4.00	8	
Wagoner	Yes	3.20-4.00	8	Less
Oregon:				
Astoria	Yes	5.50	8	5.50
Corvallis	Yes	5.00	8	4.00
Eugene	Yes	4.00-5.00	8	3.50-4.00
Salem	Yes	4.50	8	3.50-3.75
Pennsylvania:				
Allentown	Yes	5.00	10	Lower
Altoona	Yes	4.00-6.00	10	3.00-4.00
Beaver Falls	Yes	6.00	10	4.00
Berwick	Yes	4.05	9	3.00-3.60
Bethlehem	Yes	0.40	....	0.32
Bloomsburg	....	3.50	8	....
Bowmanstown	Yes	3.50	10	3.00
Chester	Yes	5.00	10	4.00
Connellsville	Yes	4.50-5.00	9	Lower
Dorranceton	....	3.20-4.00	8	Same
Dormont	Yes	6.00	10	....
Duquesne	Yes	6.00-6.50	10	....
East Bangor	Yes	4.00	10	3.00-3.50
Easton	....	....	....	0.30-0.35
Ellwood City	Yes	5.00	9	4.00-4.50
Franklin	Yes	4.00	8	....
Freeland	Yes	4.50	9	Lower
Gallitzen	Yes	5.00	9	4.50
Harrisburg	Yes	0.40	8	0.30
Huntington	Yes	4.00	10	3 00
Johnstown	Yes	5.00	10	....
Lebanon	Yes	4.50	10	3.50-4.00
Lehighton	Yes	3.50	10	3.00
Mechanicsburg	Yes	4.00	8	3.50
Monongahela	Yes	5.00	8	Lower
Norristown	Yes	4.50	9	0.35-0.40
North Braddock	....	4.20	10	4.20 or less
Oil City	Probably not	4.00	8	About same
Parkesburg	Yes	2.00	10	Same
Pottsville	....	4.50	9	....
Rankin	Yes	4.50	10	About same
Reading	Yes	5.00	10	3.50
Schuykill Haven	....	5.00	10	About same
Scranton	Yes	4.50	9	4.50
Sharon	Yes	5.00	9	4.50
Slatington	Yes	3.50	10	3.00
Stroudsburg	Yes	4.00	9	Less
Sawyersville	Yes	0.40-0.50	9	Same
Titusville	Yes	0.50	..	0.40
Tyrone	Yes	3.50	10	
Uniontown	Yes	4.50-5.50	9	Same or lower
West Homestead	....	4.50	10	3.50
Wilkinsburg	Yes	6.00	10	Lower
York	Yes	5.00	10	3.50-4.00
Rhode Island:				
Bristol	Yes	3.60	9	3.60
Woonsocket	Yes	0.50	..	Less
South Carolina:				
Charleston	Yes	2.00-2.50	9	2.00-2.25
Greenville	Yes	2.50	10	2.25

UNSKILLED LABOR IN UNITED STATES CITIES (Continued)

Cities and States	Enough unskilled labor for 1921 public works?	Present prevailing wages	Hours per day	Probable wages next spring
South Carolina (Continued)				
Greenwood	Yes	2.50	10	2.50
Orangeburg	Yes	0.20		0.15
Union	No	2.50	10	Perhaps less
South Dakota:				
Mitchell	Yes	5.50	10	5.00
Rapid City	Yes	0.60	..	Same or less
Tennessee:				
Cleveland	Yes	3.50	10	2.50
Dyersburg	Yes	3.00	10	2.00
Greenville	....	3.00	10	2.00
Texas:				
Amarillo	Yes	5.00	8	4.00
Beaumont	Yes	2.75-3.50	8	2.25-2.50
Belton	Yes	3.20	8	2.80
Brenham	....	2.50-3.50	8	2.00-3.00
Brownwood	Yes	3.50-4.00	8	2.00-2.50
Clarksville	Yes	2.00	8	1.50
Cleburne	Yes	3.50	8	2.50
Corpus Christi	Yes	2.50	8	2.50
Dallas	Yes	3.50	8	3.00
Ennis	Yes	3.00	8	3.00
Galveston	....	4.00	8	3.20
Greenville	Yes	3.00	8	2.50
Longview	Yes	2.50	8	Same or less
Mineral Wells	Yes	3.50	8	3.00
Port Arthur	Yes	3.75	8	Lower
San Angelo	Yes	3.50	8	2.50-3.00
Temple	Yes	3.50	8	3.00
Waco	Yes	3.50	8	About same
Waxahachie	Yes	3.00	8	2.50
Weatherford	....	3.50	8	3.00
Utah:				
Ogden	Yes	3.50-4.00	8	3.50
Provo City	Yes	4.50	8	4.00
Vermont:				
Burlington	Yes	3.50	9	3.00 or less
Middlebury	Yes	0.35	9	0.30
Montpelier	Yes	4.00	48 hrs. a week	Same
St. Albans	Yes	3.25	9	About same
Springfield	....	4.00-4.50	9	3.50-4.00
Virginia:				
Charlottesville	Yes	3.00	10	2.50
Clifton Forge	Yes	3.60	9	3.00
Danville	Yes	3.50-4.00	10	3.00-3.25
Hampton	Yes	0.35	9	Less
Newport News	Yes	0.40-0.44	8	0.35-0.40
Norfolk	Probably	3.60	8	3.00
Pulaski	....	3.00	8	Lower
Washington:				
Charleston	Yes	5.00	8	4.00-4.50
Chehalis	Yes	5.00	8	4.50-5.00
Okanogan	Yes	4.00	8	4.00
Olympia	Yes	6.00	8	4.50
Port Townsend	Yes	4.00-4.50	8	Not much lower
Raymond	Yes	5.50	8	5.50
Spokane	Yes	4.50	8	4.00
Walla Walla	Yes	5.00-6.00	8	4.00-4.50
West Virginia:				
Fairmont	....	0.50	....	0.40
Parkersburg	Yes	4.50	9	4.00
Wisconsin:				
Appleton	Yes	5.00	9	Less
Augusta		3.00	10	3.00
Baraboo	Yes	0.35	....	Same
Beaver Dam	Shop work, yes; other no.	4.50-6.00	10	4.00
Beloit	Yes	5.00	10	3.00-4.00
Delavan	Probably	5.00	10	4.50-5.00
Eau Claire	Yes	0.45	8	0.35-0.40
Kaukauna	Yes	4.00	10	3.00
Madison	Yes	5.00	9	4.50
Manitowoc	Yes	0.50	8-10	0.50
Marinette	Probably	4.00	10	....
Oshkosh	Probably	5.40	9	5.00
Racine	Yes	4.00-5.00	10	Same or lower
Rhinelander	Yes	4.25	8	4.00
Sheboygan	Yes	4.50	10	3.15-4.05
Superior	Yes	5.00	10	Less
Waukesha	Yes	0.35-0.40	9	0.30-0.35
Wisconsin Rapids	Probably not	4.00	8	4.00

The above data were received prior to January 20th, and tabulation begun on that date. The tabulation below includes those received after that date and up to February 1st.

Alabama:				
Gadsden	Yes	$3,00	10	$3.00
Arizona:				
Douglas	Yes	3.00	8	2.75
Prescott	Yes	5.00	8	4.00
Winslow	Yes	4.50	8	Less
Arkansas:				
Pine Bluff	Yes	2.50	10	2.00
California:				
El Centro	....	4.00	8	3.50
Pasadena	Yes	4.50	8	Same
San Luis Obispo	Yes	4.50	8	4.00
Canada:				
Toronto, Ont.	....	.60	....	....

UNSKILLED LABOR IN UNITED STATES CITIES (Continued)

Cities and States	Enough unskilled labor for 1921 public works?	Present prevailing wages	Hours per day	Probable wages next spring
Colorado:				
Boulder	Yes	3.25	8	3.00
Salida	Yes	4.50	8	3.50-4.00
Connecticut:				
Ansonia	Yes	4.00	8	
Derby	Yes	4.00	8	
Milford	Yes	.50	9	.40
Norwich	Yes	4.00	8	Same
Shelton	....	.65	....	....
Stamford	Yes	4.00	8	3.50
Waterbury	Yes	.30-.35	9	.25-.30
Georgia:				
Augusta	Yes	.25	9	.25
Idaho:				
Couer d'Alene		4.00	8	4.00
Illinois:				
Cairo	Yes	.35		.20
Chicago Heights	Yes	.70	9	
Cicero	Yes	7.00	8	7.00
Decatur	Yes	4.50	9	4.50
Evanston	Yes	5.00	8	
Moline	Yes			.40-.45
Oak Park	Yes	.60	8	.60
Olney		3.00	9	
Quincy		.45		.40
Savanna	Yes	.50	9	
Wheaton	Yes	7.00	10	7.00
Wilmette				.50
Zion	Yes	5.40	9	4.50
Indiana:				
Crawfordsville	Yes	4.00	8	4.00
Evansville	Yes	4.50	10	3.50-4.00
Kokomo	Yes	4.00-5.00	10	3.00-3.50
New Albany	Yes	4.00	10	3.50
Wabash	Yes	4.00-4.50	10	.30-.40
Iowa:				
Knoxville		3,20-4.00	8	Same
Kansas:				
Arkansas City	Yes	5.00	8	4.00-5.00
Columbus	Yes	3.20	8	3.20
Kansas City	Yes	3.20	8	Same or less
Wellington	Yes	4.00	8	3.60
Louisiana:				
La Fayette	Yes	2.00	10	1.50-1.75
Monroe	Yes	2.50-3.00	10	2.50
Maine:				
Lewiston	Probably	4.50	9	....
Waterville	Yes	4.00	9	Less
Maryland:				
Frederick	Yes	3.50	9	3.00
Massachusetts:				
Brockton	Yes	.68	8	....
Danvers	Yes	4.25	8	4.25
Holyoke	Yes	4.75	8	
Lawrence	Yes	5.00	8	5.00
Lowell	Yes	4.50	8	4.50
Malden	Yes	4.00-4.50	8	4.00-4.50
Medford	Yes	4.75	8	
Needham	Yes	4.50	8	4.50
Newton	Yes	4.25-4.40	8	4.25-4.40
Provincetown		3.00	8	3.00
Webster	Yes	3.50	8	3.00
Michigan:				
Albion	Yes	4.50	9	3.60
Battle Creek	Probably	5.40	9	About same
Bay City	Yes	5.00	8	5.00
Holland	Yes	4.50	9	4.00
Haughton		3.00-3.50	9	About same
Ishpeming	Yes	4.75	8	4.35
Munising	Yes	4.00	10	Lower
Saginaw		.45	8	.50-.55
Minnesota:				
Chisholm	Yes	5.00	8	About same
Eveleth		5.00		
Northfield	Yes	5.00	10	3.00-4.00
St. Cloud	Yes	3.50	10	4.50-5.00
Mississippi:				
Tupelo	Yes	2.50	10	2.00
Missouri:				
Brookfield	Yes	.50	9	.40-.50
Jefferson City	Yes	3.60	9	3.60
Maplewood	Yes	.55		.45-.50
Poplar Bluff	Yes	2.00	10	1.75
University City	Yes	2.80	8	.30
Montana:				
Havre	Yes	4.80	8	4.80
Missoula	Probably	5.00	8	
Nebraska:				
Nebraska City	Yes	.50	10	.35-.40
North Platte	Yes	7.00	10	6.00
New Jersey:				
Bridgeton		3.60	9	3.00
Long Branch	Yes	4.00	8	Lower
Millville	Yes	3.50	9	3.00
Orange	Yes	5.00	8	4.00
Roosevelt	Yes	4.50	9	3.60
Roselle Park	Probably	6.00	9	5.50
West New York	Yes	5.00	8	5.00
New York:				
Albany	Doubtful	4.40-5.20	8	3.50-4.50
New York, Bronx Borough		5.00-6.00	8	Lower
Ellenville	Yes	3.00	9	2.50
Elmira	Yes	4.00	8	4.00

UNSKILLED LABOR IN UNITED STATES CITIES (Continued)

Cities and States	Enough unskilled labor for 1921 public works?	Present prevailing wages	Hours per day	Probable wages next spring
Glens Falls	Probably	4.00	8	About same
Hastings-on-Hudson	Yes	3.25	8	3.25
Hornell	Yes	4.80	8	4.00
Ithaca		4.00	8	About same
Jamestown	Yes	4.00	8	
Lockport		5.00	8	5.00
Port Chester	Probably	5.00	8	4.00
Syracuse	Probably	3.20	8	Same or lower
North Carolina:				
Asheville		3.00	8	2.00
North Dakota:				
Grand Forks	Yes until fall	4.00-5.00	9	5.00-6.00
Ohio:				
Marysville	No	4.00	10	4.00
Niles	Yes	5.00	10	5.00
Sidney	Yes	3.00-3.50	10	2.75-3.00
Washington, C. H.	Yes	3.25	8	
Oklahoma:				
Hobart	Yes	4.00	8	4.00
Lancaster	Yes	4.00	8	No more
Pennsylvania:				
Bradford		5.00-6.00	8	Not less than 4.00
Clearfield	Yes	4.00	8	3.50
Corry	Yes	4.50	9	No change
Dickson City	Yes	4.00	8	4.00
Erie	Yes	4.50-6.00	10	
Greenville	Doubtful	.50		.50
Hanover	Yes	3.50	10	3.50
Hazelton	Yes	4.50	10	
Hollidaysburg		4.50	10	
Jersey Shore		4.50	9	3.00-3.50
Media		4.50	8	Lower
Philadelphia	Yes	.45-.50		.45-.55
Pittsburgh	Yes	4.00	10	3.50
Punxsutawney		3.50	10	About same
Sayre	Yes	3.50	9	3.00
Summit Hill		5.00	10	.50
Wilkes-Barre	Yes	.40	9	.40
Woodlawn		5.00	10	
Rhode Island:				
Newport	Yes	4.00	8	4.00
Pawtucket	Probably			
South Carolina:				
Manning	Yes	1.50	10	
Spartansburg	Yes	.20	10	.15
South Dakota:				
Aberdeen	Yes	.40-.50		.35-.45
Sioux Falls	Probably	4.80	8	4.00
Watertown	Yes	4.00-5.00	10	4.00
Tennessee:				
Clarksville		2.50	10	2.00
Texas:				
Bonham	Yes	2.50-3.50	8	2.50
Childress	Yes	4.00	8	3.00-3.50
Cisco	Yes	4.00	8	3.00
Eastland	Yes	4.00	8	3.50
Utah:				
Brigham City	Yes	5.00	8	5.00
Vermont:				
Barre	Probably	4.00	8	4.00
Bennington		4.80	8	
Virginia:				
Roanoke	Yes	3.60	9	3.60
Washington:				
Auburn	Probably	5.20	8	4.00
Port Angeles	Yes	5.00	8	4.50
West Virginia				
Grafton	Yes	3.50	10	3.00
Moundsville	Probably	3.60	9	Lower
Princeton	Yes	.45	9	.40
Wisconsin:				
Ashland	Yes	3.50	8	3.00
Edgarton	Yes	5.00	10	Same or less
Janesville	Probably not	4.50	9	5.00
Jefferson	Yes	4.00	8	
Lake Geneva	Yes	4.50	9	4.00
Menasha	Yes	.50	9	.50
Neenah	Yes	.50	9	.50

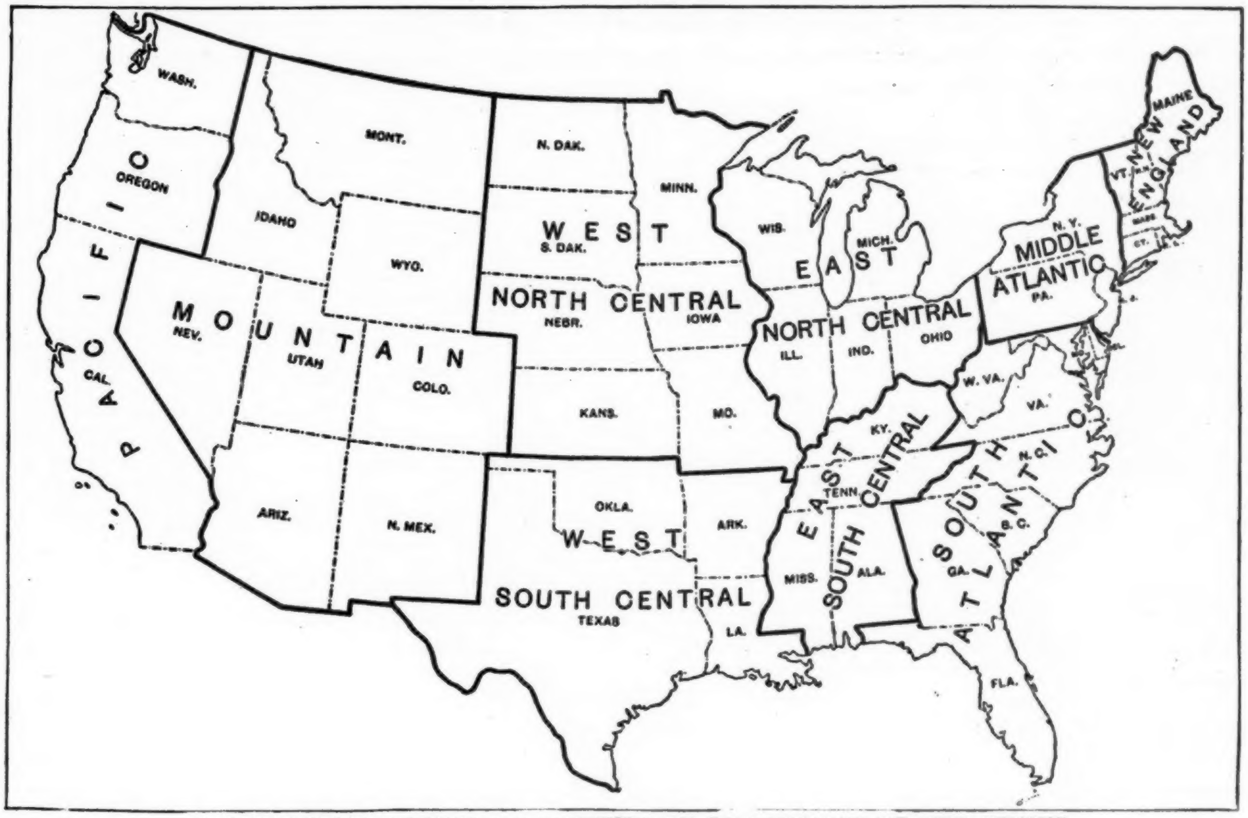
(*Continued from page* 121)

these percentages were as follows: New England, 8; Middle Atlantic, 11⅓; South Atlantic, 11½; East North Central, 11½; East South Central, 24¼; West North Central, 12¼; West South Central, 14⅔; Mountain, 12¼; Pacific, 11⅓.

It will be noted that of the nine groups, 6 anticipate a reduction of 11 and a fraction or 12 and a fraction percent; a seventh, 14 and a fraction percent; while the other two give 8 and 24, respectively. The 24 per cent of the East South Central is caused by the anticipated drop to an average wage of 25 cents per hour, which is by far the lowest average reported from any section. The relatively small anticipated drop in New England is caused by the comparatively low average of existing wages.

Another feature of the uniformity lies in the geographical distribution of the wage averages. Taking the anticipated 1921 wages, we find the northern tier of states, that is, New England, Middle Atlantic, East North Central and West North Central to report the wages as 46, 45, 46 and 43 cents, respectively; while the South Atlantic, East South Central and West South Central report 30, 25 and 35 cents, respectively.

A summary by geographical divisions has been made of the data contained in the complete table,



GEOGRAPHICAL DIVISIONS AS DEFINED BY THE BUREAU OF THE CENSUS.

giving not only the average, but also the maximum and minimum reported for each division. These show that, although the averages seem to follow a definite law, there are considerable variations within each division. For instance, in the Middle Atlantic division we find wages varying from 20 cents to 75 cents per hour, in the East North Central from 30 cents to 87 cents, etc.

Taking the entire country, we find the average wage at the present time is 48 cents an hour and that the average of the wages anticipated for next spring is 42 cents an hour, a reduction of 13 per cent.

It is to be noted that the drop in wages is not so great as it would have been had the question been asked a few weeks ago, the "present wages" being those of January, 1921, and not those of last summer and fall. For instance, one town in New Jersey reports the present prevailing price of labor as $4.50 per day, but that it has just been reduced from $5.50; while a North Carolina city reports that the wages there have just been cut from $4 to $3; these two showing a recent fall of 25 per cent in addition to the further fall anticipated. We had expected to learn of a greater anticipated reduction than that shown by the table, approximating more nearly to pre-war prices, especially in view of the apparent abundance of labor everywhere. It would seem, however, that reliance should be placed upon the opinions of these hundreds of observers, especially in view of the great uniformity of their ideas on this point.

Fortunately, reports from contractors (although by no means so many of these have reached us as the replies to the above questions) indicate that the efficiency of labor of all kinds has increased greatly and has recovered from 50 per cent to 100 per cent of its former departure from pre-war effectiveness.

SUMMARY OF GEOGRAPHICAL DIVISIONS

State Group	No. of cities reporting	Present Wage Per Hour			Probable Wage in Spring			Average percentage reduction
		Av.	Max.	Min.	Av.	Max.	Min.	
New England	39	50	65	35	46	62½	25	8
Middle Atlantic	61	53	75	20	45	62½	20	11 1-3
South Atlantic	24	34	69	20	30	53	15	11¾
East North Central.	98	52	87½	30	46	87½	30	11½
East South Central..	10	33	53	25	25	44	15½	24¼
West North Central.	51	49	65	35	43	62½	30	12¼
West South Central.	28	41	62½	25	35	62½	19	14 2-3
Mountain	16	57	69	40	50	56¼	33 1-3	12¼
Pacific	20	62	75	50	55	75	37½	11 1-3
United States	347	48	87½	20	42	87½	15	13

BASE AND SUBGRADE FAILURES

City and State	What kind of pavement base has failed?	Thickness of base, inches	Wearing surface	Was failure due to traffic?	Description of traffic	Was failure due to yielding of subgrade?	Cause of yielding
Arizona:							
Bisbee	Concrete	6	Brick	No		Yes	Pipe trenches and poor repair.
Arkansas:							
Little Rock	Concrete	5	Asphalt Concrete	No	Very light		Improper drainage and thin mix
California:							
Anaheim	Concrete	4½	Asphalt			Yes	Pipe trenches
Calexico	Concrete	5	Warrenite	Yes	750	Yes	Settlement of new embankment
Napa	Bituminous Concrete	3	Natural Bitumen	No		No	Not properly constructed and too high a crown
Palo Alto	Macadam & Concrete	4	2 in. Bit. Rock	Yes		No	
Porterville	Asphalt Concrete	4	None	No		Yes	Nature of soil Adobe changes volume with wet and dry seasons
Ventura	Concrete	4	1 in. Warrenite	Yes	Heavy trucks		
Colorado:							
Leadville	Macadam	4	2 in.	Yes	About 1,000 per day, light rigs to heavy auto trucks and ore wagons weighing up to 15,000 lbs.	Yes	Improper replacement of surface after excavation
Connecticut:							
Hartford	Cement Concrete	6	3 inch sheet asphalt			Yes	Pipe or conduit trench
Meriden	Concrete	6	Wood block	No		No	Probably due to poor construction
Florida:							
Sanford	Sand		Brick			Yes	Lack of drainage
Georgia:							
Albany	Concrete	6	Brick				Old ditch lines, cracks in sub-base
Illinois:							
Canton	No. 2 brick	2¼	Small pavers	Yes		Yes	Lack of drainage; trench openings made after pavement was laid
Carlyle	Macadam	6—8	Macadam	Yes	Fords to 7-ton trucks	No	No surface binder
Centralia	Natural Cement	6	Brick	No		Yes	Poor material
Danville	Concrete	5	Bitulithic	Yes	12-ton trucks	Yes	Lack of drainage or wet spots on slopes
Galena	Old Macadam	6—24	Vit. Block	No		Yes	Mostly pipe trenches
Joliet	Macadam	6	3½ in.	No		Yes	Poor drainage
La Grange	Concrete	6	Asphaltic Concrete	No		Yes	Where 36 in. fill was laid through old swamp; stood 4 years then settled slightly
Pana	Concrete	5	Brick 5 in. Sand Cushion	No	Light traffic	Yes	Black undrained soil, damp when pavement laid
Taylorville	Concrete	6	Brick & Vitrified Block	No	Fords to 10-ton trucks	Where service pipes were newly laid in advance of paving	Improper back-filling; also a street railroad was laid in cold weather and pavement not properly replaced
Waukegan	Macadam	6	Brick	No		Yes	Pipe trenches
Winnetka	Concrete	5	Brick, Tar Filler	Yes	Heavy motor truck traffic	Yes	Clay sub-soil; base too light; loads too heavy and fast
Indiana:							
Covington	Sand and Clay	4	Brick	No	All kinds of vehicles	Yes	Lack of drainage
Crown Point	Slag	6	Crushed Limestone	Yes	100 5-ton; 500 1 and 2-ton trucks; 1,000 autos	No	Neglected repairs to wearing surface
Elkhart	Concrete	6	2½ inch Asphalt	No	Ordinary traffic	Yes	Pipe trenches and mucky sub-soil
Elwood	Gravel & Sand	10	Brick	Rutting under truck traffic in early spring	Average 120 trucks 3-5-10-ton, 400 autos daily	No	Partly fill; pushing of gravel and sand under weight
Franklin	Gravel	12	Brick	No			Poor drainage, causing surface to settle and blow up
Huntington	Stone	8	Brick	No		Yes	Trenches and drainage
South Bend	Concrete	5	Sheet Asphalt	Yes	Heavy truck traffic	No	Concrete in base not first class
Terre Haute	Stone & Gravel	12	Brick	No		Yes	Pipe and sewer trenches
Iowa:							
Boone	Natural cement Concrete	5	Brick	Yes	Heavy traffic of all kinds		
Centerville	Concrete	5—6	Brick	Yes	5 to 10-ton trucks	Yes	Also settlement of fill in a few cases
Fort Dodge	Concrete	5	Asphalt	Probably		Yes	
Muscatine	Macadam			Yes	10 to 20-ton trucks	Yes	Poor filling of gas and sewer trenches, especially when done in winter and soils not thawed out when refilled

BASE AND SUBGRADE FAILURES—(Continued)

City and State	What kind of pavement base has failed?	Thickness of base, inches	Wearing surface	Was failure due to traffic?	Description of traffic	Was failure due to yielding of sub-grade?	Cause of yielding
Kansas:							
Council Grove	Concrete	5	Brick	No		Yes	Base has cracked due to expansion and contraction of sub-base
Dodge City	Concrete	5	3 in. vertical fiber Brick block	No	300 autos; 100 horse-drawn vehicles	Yes	Contraction and expansion of base
Independence	Crushed Rock	6	Brick	Partially			Pipe trenches and bad drainage of sub-soil
Manhattan	Concrete	5	Asphaltic Concrete	No		Yes	Pipe trenches in some cases and lack of drainage in most cases
McPherson	Concrete	4	Asp. Concrete & Brick	No		Yes	Gumbo sub-soil
Salina	Macadam	6	2. in	Yes	1 to 5-ton trucks; 3,000 a day	No	Bad mixture of asph. and aggregate
Ottawa	Concrete	5	Brick	Yes		Yes	Gumbo soil mostly
Winfield	Concrete	4	3 in. Brick	No	Autos and trucks	Yes	Shrinkage of gumbo sub-soil in drying
Maine:							
Bangor	Cement Conc. base	6	Wood block	No		Yes	Pipe trenches and lean concrete.
Massachusetts:							
Lee	Stone	6	Water-bound Macadam	Yes		Yes	Lack of drainage
Michigan:							
Detroit	Concrete	6	Asphaltic		Mostly 5-ton trucks	Yes	Pipe trenches mostly—poor filling material in made ground
Muskegon	Concrete	3—7	Concrete	Yes			
Port Huron	Concrete	6	Brick	Yes		Yes	Sawdust fills
			Brick	No		Yes	Lack of drainage—freezing
Sturgis	Concrete	6	Brick	No		Yes	Pipe trench
Ypsilante	Concrete	7	Concrete	No		Yes	Lack of drainage and hard compacted centers with uncompacted gutters
Minnesota:							
Albert Lea	Concrete	5	Wood-block	No		Yes	Across old slough bed peat soil.
St. Peter	Gravel	8—10	Gravel	Yes		Yes	Heaving caused by freezing of hard-pan under sub-grade.
Mississippi:							
Clarksdale	Concrete	5	1½ in. Asphaltic Concrete	No		Yes	Defects in Sewer lines
Missouri:							
Sedalia	Macadam	6	Vit. Brick	No		Yes	Pipe trench—lack of drainage
Montana:							
Billings	Concrete	4	1½ in. Bitulithic	Yes	600-800 some trucks weighing 12 to 15 tons	Yes	Lack of drainage; water table so near surface as to soften sub-grade
Great Falls	Concrete	4	2 in.			Yes	Heaving of ground
Lewiston	Concrete	6	Bitulithic	No		Yes	New embankment at bridge approaches
Nebraska:							
Lincoln	Concrete	5—8	Brick & Asphalt	No		Yes	Generally heaving due to frost at points of leaking water mains or services
Norfolk	Concrete	5	2 in. A. C.	No		Yes	Trenches and excessive frost upheaval
New Hampshire:							
Laconia	Cement Concrete	6	Tar Concrete	No		Yes	Lack of drainage
Portsmouth	Concrete & Gravel	6	Sheet Asphalt			Yes	Frost heaving small amt. of new work where new trenches were, or, improper drainage
New Jersey:							
Montclair	Concrete	5	Asphalt Macadam	No		Yes	Street built over ash-filled ground
New Brunswick	Concrete	5—6	Brick or Asphalt	No		Yes	Ditches for sewer, water or gas
Ridgefield Park	Broken Stone	4	3 in.			Yes	Wet clay soil—improperly drained—considerable traffic
Rutherford	Broken trap & Concrete	4½	2—1½ in. with "C" grade Asphalt	No	Auto trucks, 2 to 6 tons probably 2,000	Yes	Red clay in bottom 14 in. cut
New York:							
Binghamton	Concrete	6	Brick	No		Yes	Pipe trench
Buffalo	Natural Cement Concrete	6	Asphalt	Yes		Yes	Drains each side—but not sufficient
Corning	Concrete	6	Brick	No	Motor trucks and pleasure cars, maximum weight 6 tons	No	From the deterioration of gravel used in concrete base
Gloversville	Concrete	5—6	Vit. Brick	Yes		Yes	
Herkimer	Concrete & Crushed stone	4—5	2 in.	No		Yes	Sewer trenches
Manhattan	Concrete	6	Asphalt, Granite & Wood	Yes		Not usually	Water leaks washing materials into bad filling elsewhere
Niagara Falls	Concrete	4		Yes		Yes	Pipe trenches and heavy traffic
Ogdensburg	Concrete	6	Brick	No		Yes	Trenches filled with clay
Oneonta	Concrete	6	Brick	No		Yes	

BASE AND SUBGRADE FAILURES—(Continued)

City and State	What kind of pavement base has failed?	Thickness of base, inches	Wearing surface	Was failure due to traffic?	Description of traffic	Was failure due to yielding of sub-grade?	Cause of yielding
North Carolina:							
Durham	Concrete	6	3 in.	No		Yes	St. Ry. Co.'s faulty track construction
Fayetteville	Gravel & Clay	9	Durax blocks				
Statesville	Concrete	4	2½ penetration Tarvia Macadam	No		Yes	Base was laid with lap joints and they telescoped
Wilson	Concrete	4		Yes	Heavy trucks	Yes	Pipe trench—probably bit; base too light for traffic
Ohio:							
Akron	Crushed Slag & Sand	6	Brick	Yes	Heavy hauling	Yes	Clay soil—no drainage; hauling with trucks while soft
Alliance	Gravel	6	Asphalt Blocks 4 in.	Yes	10-ton trucks 400 to 500 total of vehicles	Yes	Lack of drainage with poor base
Bucyrus	Rolled Stone	6	Brick	No		Yes	Lack of drainage
Chillicothe	Concrete	5—6	Brick & Asphalt Block	Yes	Very heavy		Lack of thorough compaction of trench
Delaware	Concrete	6—4	Brick & Asphalt Block	No		Yes	Embankment on brick and pipe trench on asphalt
Lakewood	Rolled Cinders	6	4 in. Brick	Yes	Occasional 10-ton trucks	Yes	Most failures over improperly placed fill in old trenches
Lancaster	Rolled Gravel	6	Brick	No		Yes	Due to sewer trenches—backfilling carelessly done and sub-grade not properly rolled
Lorain	Concrete	6	Asphalt	Yes		Yes	Trenches
Marietta	Sand & Gravel		Brick	Yes	Trucks	Yes	
Marion	Rolled Stone	8	Brick	Yes		Yes	
Norwalk	Concrete	6	Brick	No		Yes	Lack of drainage
Wooster	Stone	1	Brick			Yes	Local stone used in foundations gave way—may not have been properly tamped
Zanesville	Gravel	6	Brick			Yes	Lack of drainage
Oklahoma:							
Durant	Concrete	4	Asphalt Macadam	No		Yes	Lack of drainage "alkali" soil
Oregon:							
Astoria	Crushed rock, Concrete	5—6	Bitulithic	No		Yes	Slides and settlement due to excessive rain-fall and to foundation which is mostly soapstone
Corvallis	Port. cement Concrete also Black base	4	Asphaltic Concrete	Yes		Yes	Lack of drainage
Eugene	Black & Concrete	3½—4	1½ in. Bit. & Sheet Asphalt	Yes	quite heavy	Yes	Lack of drainage and lack of thickness and quality in concrete base
Pennsylvania:							
Allentown	Concrete	4	1 in. Binder, 1½ in. asphalt	Yes		Yes	Trenches
Altoona	Concrete	6	Brick & Sheet Asphalt			Yes	Trenches and insufficiently rolled sub-grade; inadequate drainage
Chester	Concrete	6	2 in. Sheet Asphalt	Yes	heavy commercial	Yes	Pipe trench
Dormont	Concrete	5	Brick, Sand Cushion	Yes	Sand and material trucks, gross weight about 25,000	No	Some failures due to new or not sufficiently rolled embankment
Duquesne	Gravel	8	Brick	Yes			
Easton	Concrete	5	Brick	Yes		Yes	Yielding of sub-soil after concrete became shattered due to inferior concrete
Monongahela	Slag, Gravel	7	Brick	Yes	Motor trucks	Yes	Sewer and other street openings
Norristown	Concrete	4—5	Vitr. brick	No	Quite heavy	Yes	By leaking water mains and services, surface water freezing; disintegrating surface pavement
Rankin	Gravel & Sand	6 gravel 2 sand	Brick	Yes	3,600 heavy trucks and pleasure cars	Yes	Pipe trenches and lack of drainage—foundation not strong enough for heavy trucks
Sharon	Gravel & Slag	3—6	Brick, conc. & Asph. Block	Yes		Yes	As block pavements worn out because of blocks wearing—base good
Tyrone	Concrete	6	Vitrified Brick	Yes	Trucks carrying stone for highway contractors	No	Disintegration of concrete
Uniontown	Crushed Stone	6—8	Brick	Yes	Heavy trucks, hauling coal, weigh from 3 to 15 tons	Yes	Mostly pipe trenches, some due to improper drainage
Rhode Island:							
Bristol	Clay	3	Tar Concrete	No		Yes	Lack of drainage

BASE AND SUBGRADE FAILURES— (Continued)

City and State	What kind of pavement base has failed?	Thickness of base, inches	Wearing surface	Was failure due to traffic?	Description of traffic	Was failure due to yielding of sub-grade?	Cause of yielding
South Carolina:							
Greenville	Concrete	3	Asphalt	Yes			Base too thin—car tracks not properly laid
Union	Concrete	4	1 in.				
Texas:							
Amarillo	Vibrolithic	7	Vit. Concrete	No		No	Lack of sufficient expansion joints
Brownwood	Clay or soil		8 to 10 in.	No		Yes	No proper foundation
Clarksville	Waterbound Macadam	6	Asphalt penetration, 2 in.	No	400 autos; 100 wagons and buggies	Yes	Lack of drainage
Corpus Christi	Concrete	4—5	Bitulithic	No		Yes	Black gumbo sub-soil
Greenville	Concrete	4	Brick & As. Concrete	No		Yes	Water main leaks subsequent settlement
Longview	Macadam	6	Asphalt Macadam	No		Yes	Lack of drainage
Waxahachie	Concrete	5	Asphaltic Concrete 2 in.	No		Yes	Black land foundation over limestone. Under ground water running on top of limestone
Port Arthur	Concrete	4	2 in. Asphalt	No			
Temple	Concrete	5	2 in. Asphaltic Concrete	No		Yes	Gaps in pavement allowed water to get in under base
Virginia:							
Danville	Crushed Stone	6	Brick	No		Yes	bursting of water mains and caving of under ground storewater drains
Newport News	Concrete	8	Concrete	No		Yes	Lack of drainage
Norfolk	Concrete	4—5	1¼ binder 1½ in. top Asphalt	Yes	Motor trucks, 10 to 15 tons	Yes	Pipe trenches
Washington:							
Chehalis	Concrete	6	Brick		750 vehicles a day, max. weight 15 tons	Yes	Sewer trench not settled prior to paving
Olympia	Concrete	4	2 in.			Yes	Pipe trench and lack of drainage
Walla Walla	Bit. & Port. Cem. Con.	2½—4	Bitulithic & Sheet Asphalt	No		Yes	Settlement of trenches
West Virginia:							
Fairmont	Concrete	5	Brick	No		Yes	Pipe trenches badly back-filled
Wisconsin:							
Racine	Concrete & Crushed stone	5—6	Brick	Yes	Trucks over 12 tons	Yes	Pipe trenches under concrete and softening of crushed stone when frost comes out in spring
Sheboygan	Concrete	6	Brick	No		Yes	Large yardage of soil underlaid with quicksand hard to drain sufficiently to prevent heaving from frost under low temperatures
Superior	Concrete	5	Creo. blocks & Asphalt	Yes	Heavy trucks	No	Weak concrete base
Waukesha	Hyd. Cement Concrete	4—6	Brick	Yes	Motor trucks	Yes	Pavement sunk over trenches due to sub-soil being gravel and hard to get into shape
Wis. Rapids	Concrete	6½	Concrete	No		Yes	Lack of drainage

Failures of Pavement Bases

Causes of failures in several hundred cities. Subgrade more commonly responsible than traffic. Sixty per cent of cities had no base failures.

The opinion is growing that more pavement failures than was formerly realized are due to the base rather than to the wearing course. Most wearing courses are poorly adapted to performing the functions of a base or foundation and if the base or subsoil under them fails, the wearing course must fail also.

In order to obtain some information on this subject, covering the various conditions found throughout the country, we included in a recent questionnaire sent to city engineers, certain inquiries concerning failures of pavement bases in their respective cities. Of the first 460 replies received to these and other questions, 139 failed to reply to the questions concerning base failures. Of the 321 who replied, 196 reported that no pavement bases had failed in their cities. The data given by these replies have been tabulated, the tables being published in this issue.

The following information on this subject has been obtained by summing up the tabulated data and also from supplementary explanations given on the returned questionnaires.

Of the various bases reported upon, 87 were concrete, 3 were bituminous concrete, 29 were macadam or gravel, 2 were slag and 3 were sand and 1 was brick.

The informants were asked to state whether the

CONCRETE BASE UNDER ASPHALT BLOCK (BOSTON POST ROAD, NEW YORK) DESTROYED FOLLOWING SOFTENING OF SUB-GRADE BY SPRING THAW

pavement had failed because of traffic or because of a yielding of the sub-soil. Of the concrete bases 49 were reported as having yielded because of sub-soil, 8 because of traffic, 5 because of poor construction of the base, and 25 because of combinations of these. If we combine failures due both wholly and partly to each of the several causes, we find 73 from soil weakness, 32 from too heavy traffic and 7 from poor construction, percentages of 66, 28 and 6 respectively. Of the bituminous concrete, one failure was reported due to soil alone and two to both soil and traffic. Of the macadam and gravel roads the soil was responsible for 13 failures, traffic for 3, and 13 were due to a combination of these and poor construction. Combining these as above, we find 25 due to soil, or 60 per cent; 14, or 33 per cent, due to traffic; and 3, or 7 per cent, due to poor construction. Of three cities reporting sand base failures, two reported such failure due to sub-soil and one to traffic. Of the two slag bases, one failed because of traffic and the other because of both traffic and sub-soil. The one failure of brick base was reported due to a combination of traffic and sub-soil.

Combining all of the failures of the various kinds of pavement, we find 104 due to sub-soil, 51 to traffic and 10 to poor construction.

Of the failures attributed to the sub-soil, the majority were on account of the settling of the back-filling of trenches. In some cases the streets had been laid upon embankment which continued to settle. Several of the cities, chiefly in the southwestern part of the country, referred to the phenomenon of excessive shrinking of the gumbo soil, which sometimes opens up cracks two inches or more wide, the tendency of which is of course to crack open the base immediately above such cracks in the sub-soil.

Second only to pipe trenches as a cause of failure of the sub-soil was poor drainage of wet soils. One city engineer in Kansas who attributed failure to "shrinkage of gumbo sub-soil" adds that "Recent paving has not failed. We use more care and lay mostly 5-inch base. Through some base I have laid a reinforcing rod transversely each 30 feet." In this city the base which was reported to have failed was 4-inch concrete.

A Pennsylvania city reported a brick pavement on a 5-inch concrete base to have failed because of the joint between the base and the combination curb and gutter; also that some failures had been due to embankments which had not been sufficiently rolled.

Several engineers explained the freedom of their pavement bases from failure. For instance, one North Carolina city engineer stated: "The entire city is underlaid with sand, forming an ideal natural foundation. The brick pavement is mostly 18 years old, on sand foundation with cement grout, and except where it has been cut is in as good condition as when it was put down. The asphalt macadam has been down 10 years and is good for about one year more." In this city both brick and asphalt macadam were laid on the natural sand soil. A Connecticut city engineer writes: "The sub-soil drainage in this city is excellent, in view of which we are able to resurface old macadam pavements with sheet asphalt (1½ inch binder, 1½ inch top) with gratifying results." Another Connecticut engineer writes, "I have used 2½-inch to 3-inch broken stone bases bound with sand on heavy traffic streets with 2½-inch to 3-inch asphalt macadam stone on sand and clay sub-base and have never had a failure. The failure in many places is due to poor drainage and small crushed stone for the base."

The general impression given by the various replies is that failure of pavement bases is due to traffic in not more than one-third or one-fourth of the cases of failure, most of the balance being due to failure of the sub-soil either over imperfectly compacted trenches or because of yielding due to poor drainage. This general statement seems to apply to each class of base. The concrete, for which is claimed the advantage of bridging over small areas of yielding sub-soil such as trenches and wet spots, is reported to yield under such conditions in as high a percentage of cases as macadam or any other type of base.

Of the 335 cities that did not report any failures of bases, a number gave no statement on the subject, but 121 reported that there had been no failures of bases. Absence of failures was reported for 84 pavements having concrete base, 2 having asphalt concrete, 20 having macadam, 7 having gravel, 5 having sand, 1 cobblestone, and 2 with no base except hard soil.

Of the 84 pavements with concrete base that have not failed, 34 had rigid surfaces such as brick or granite block, while the remaining 50 were surfaced with sheet asphalt, bituminous concrete, and other pavements similarly adapted to cushioning the impact of traffic.

Macadam base was used under brick in two cases, and in the remaining 18 cases under bituminous macadam and bituminous concrete.

One New York city reports that the only base to fail on its streets was that of a state-built brick pavement on concrete, which failed over trenches that had recently been dug and not properly back-filled. The concrete base was reinforced with ¾-inch lug bars laid crosswise of the trenches, but these apparently were not effective. "Might better have spent the money drawing away the soggy clay to a dump and filling the trenches with old dry macadam or sand or cinders."

One Kansas city engineer stated that the contraction and expansion of a 5-inch concrete base caused

(Continued on page 137)

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Labor in 1921

There will be plenty of unskilled labor in all parts of the United States for carrying out all of the public work contemplated by the cities of the country this year, and in general the wages will be very materially lower than they were a year ago.

Of the above there would seem to be no possible doubt. It is not the opinion of one man or of a dozen men, but of six hundred city engineers distributed over the entire country from Maine to Florida, throughout the Mississippi valley, across the Rockies and on the Pacific coast. Six hundred city engineers have reported to us during the past six weeks, each concerning conditions in his own district, and more than 93 per cent stated positively that there would be plenty of labor for public works this year, and only eight of the remainder reported that there would not be plenty, the others being in doubt.

With such almost absolute unanimity of opinions coming from all parts of the country, and from men who are intimately connected with public works in their respective cities, occasional errors of judgment are buried in the general concensus of opinion. If there are a dozen or so cities where more laborers are needed, the deficiency can certainly be made up from the hundreds of other localities where they are found in abundance.

As to wages, in most localities these have already lost 50 to 75 per cent of last year's increase above pre-war rates and indications are that they will fall still lower. In fact, in some localities they have already almost reached pre-war conditions.

With satisfactory conditions as to labor, and with plenty of funds available, any restriction on public work this year will apparently be due to scarcity or high prices of materials. There would seem to be little, if any, need for the former, with abundance of labor and the railroads in condition to handle a considerable increase of traffic. It is certainly to be hoped that the manufacturers and the dealers in materials used in public work will not make themselves responsible for putting the brakes on progress in such work this year by adopting or maintaining a selfish or short-sighted policy of profiteering prices. It is also to be hoped that engineers and others in charge of public works will meet such condition, should it occur, by substituting materials offered at more reasonable prices where it is possible to do this by modifying their plans or changing types of construction.

City Streets and Highway Pavements

With the increasing use of heavy trucks over county and state highways, the wheel loads to be supported by highway pavements are probably as great as those to which the majority of city pavements are subjected; while the more popular highways carry as intense traffic as almost any city street, per foot of width. As far as traffic conditions are concerned, therefore, there would seem to be no reason for differentiating between highways and city streets in paving practice.

In the support furnished to the pavement, however, there are several features of difference. Although the same kind of soil is found in both city and country, highways have occasionally to cross swampy lands which would not be used as building sites; also city streets generally contain sewers and water mains, and frequently gas mains, wire conduits and other structures laid in continuous lines under the street surface; while the houses along the street are generally provided with cellars whose bottoms are carried lower than the street level, except in those southern states where cellars are the exception. The continuous trenches in which the underground conduits are laid serve as blind drains in the majority of cases, removing any underground water that may reach them unless it is in enormous amounts; while cellars aid in drying out the subsoil down to the level of their bottoms, either by direct action or because water in the sub-soil surrounding them cannot be tolerated and must be

removed by artificial drainage. We therefore find wet sub-grade much less common in city streets than in country highways.

Trenches, however, are objectionable in that settling of the backfilling (which is very difficult to prevent) removes the support offered by the sub-grade to the pavement, which must then either bridge over the settled area or settle in its turn and damage the pavement.

The above takes into consideration only the more self-evident points, and various local conditions will necessitate more or less important modifications of the conclusions drawn. Such conclusions, however, may be stated as follows:

On the more important highways, the same wearing surface should be used as for main city streets.

In city streets where trenches have been or will be dug, a base should be used that is able to carry the traffic by bridging over such trenches, or else special precautions should be taken to make the backfilling even more solid than the undisturbed soil.

On highways or streets not trenched, bridging ability is not so important, since the sub-base is presumably fairly uniform in supporting power. This supporting power, however, should be made the maximum possible by drainage to remove sub-soil water, by rolling to compact it, and occasionally by the use of clay, sand, gravel or other materials whereby added stability may be given to the surface.

In general, the main differences between the two classes of roads, so far as pavements are concerned, are due to the presence or absence of trenches, and to the relative freedom from ground water, which generally lowers the supporting power of the sub-grade.

Pavement Bases

Does the average paving official give sufficient consideration to the matter of pavement bases? One such official is quoted as having recently made the sweeping statement that every good pavement either consists of concrete or has a concrete base, and a great many paving engineers and others seem to assume this is axiomatic.

Another engineer has said that a clay road will give as good satisfaction under even the heaviest traffic as any kind of pavement, provided it is kept continually dry. Still other engineers have said that 90 per cent of the pavements laid would give better service at less cost if placed on a bituminous base rather than on cement concrete.

We believe that every unprejudiced engineer of wide experience will admit that the last two statements contain at least an element of truth; and yet in the great majority of cases, to an engineer deciding upon the character of a pavement, no question suggests itself as to what is the best base—he merely wonders if he can afford or the traffic justifies a concrete base, or whether he must lay the pavement without any base.

The entire load of traffic is carried by the sub-grade—the base merely transmits and distributes it. If the sub-grade has such bearing power throughout that the traffic, if carried directly upon it, will not cause appreciable depression in the surface, and if it is certain that the sub-base will retain this condition under all conditions of weather, there is no need of a base, and very little need of a wearing course other than one sufficient to prevent abrasion and dust. Pavements laid on such soil without a base twenty or thirty years ago are still in good condition.

If the sub-base is incompressible throughout, but composed of particles which may flow under localized pressures, such as dry sand, the chief function of a base is to prevent such movement of particles by distributing the pressure over larger areas and also by preventing a rising of particles above the general level when displaced by corresponding depressions under the loads applied.

Where the supporting power of the soil is not uniform, but there are small areas that would yield under pressure, the chief function of the base is to bridge over these spots and transmit the load to the more solid portions of the sub-grade surrounding them, like a floor slab supported at the edges.

Where the entire sub-grade is, or may become during wet weather, without sufficient supporting power to sustain the traffic loads without yielding unless such loads be distributed over considerable areas, it is the function of the base to so distribute the loads. In this case the slab acts much as a raft supporting a load in water, and if the soil becomes very soft the flexible base develops waves and hollows, the rigid one breaks into innumerable pieces; in either case the pavement is ruined.

In rolling a sub-grade there are very apt to be left spots somewhat less compacted than others; in fact, it is hardly practicable to obtain absolutely equal compaction over the entire area of a sub-grade. If a rigid base be employed, the areas of less compactness do not support their share of the load imposed by traffic, but the base over them must act as a floor to transmit this to the firmer soil around them. In many cases, however, if the base could yield a quarter or even an eighth of an inch, these spots would then develop as great a supporting power as the surrounding area, and the base would no longer need to exert bridging action. In the case of a flexible base, such as asphaltic concrete, this is what happens. The slight depression of an eighth of an inch necessary to establish uniform support throughout the sub-grade does not produce a defect in the pavement nearly so serious as that occasioned by a break in a rigid concrete base; and yet such a break occurs if the load applied to the rigid base over such weak spot in the sub-grade is greater than the base can support as a slab.

It follows from this that the beam strength of a non-rigid pavement does not need to be nearly so great as that of a rigid pavement in order to secure equal effectiveness of the base in performing its function.

There are other conditions under which the adaptability of the flexible base to minor sub-grade changes is of great advantage; for instance, in the case of a pavement built upon an embank-

ment which continues to settle slightly, not enough to throw the pavement objectionably out of surface but great enough to cause cracks in a rigid pavement.

On the other hand, rigid pavements are advantageous where narrow areas of depression occur in the sub-grade over which a flexible base would continue to settle for an inch or more before coming to rest, and so produce undesirable depressions in the pavement surface; while these areas, if sufficiently narrow, are bridged by a concrete base of reasonable thickness. A common illustration is that of narrow trenches, such as those for house connections, which are often bridged successfully by 6-inch or 8-inch concrete bases.

The above is merely a superficial consideration of the subject, but it is by no means purely theoretical or at all imaginary. Millions of yards of flexible base much thinner than is generally employed for rigid bases have successfully supported for years pavements carrying heavy traffic. On the other hand, it is probable that very few concrete pavements or concrete bases can be found that do not contain hundreds of lineal feet of cracks in every mile of pavement caused by the non-uniformity of the supporting power of the sub-grade.

No attempt is made in the above to even indicate exactly under what conditions rigid base, non-rigid base, or no base at all should be employed, but only to call attention to the fact that there is a question to be considered, and a serious one which involves the saving or wasting of millions of dollars every year in the construction of pavements in this country.

Our Tabulated Pavement Data

For more than a dozen years we have published about this time each year data concerning paving in American cities, obtained through the kind co-operation of hundreds of city engineers. This year the question uppermost in the minds of paving authorities is whether enough labor for all the paving work contemplated can be obtained, and at what wages. On the technical side, the question of bases is assuming the most prominent place. On both of these subjects we have collected data which are presented in this issue. Figures as to the amount of pavement laid in several hundred cities have been tabulated but are postponed to future issues for lack of space in this.

State Manufacture of Road Materials

Kansas good roads boosters claim that there is in that state a combine of dealers in road materials which is holding up prices of such materials, and they are asking the state legislature to enact a law authorizing the state to own and operate plants for manufacturing cement and brick. It is believed that such a law would be legal under the constitutional amendment adopted last fall authorizing the state to aid in the construction of state highways. The advocates of such an act also are considering submitting to the voters a constitutional amendment that would authorize the state to sell road materials so manufactured when these should exceed the demand for state purposes.

Failures of Pavement Bases

(*Continued from Page* 134)

cracks which allowed the sand cushion under brick pavements to flow out into the cracks, causing the brick to settle.

Owensboro, Ky., reports that there were no failures of either concrete or macadam base pavements, as all the streets are sub-drained along the curb. On the other hand, Buffalo, N. Y., reports that drains along each side of the pavement were not sufficient to prevent settlement of the 6-inch concrete base due to a yielding of the sub-soil. One Ohio engineer reports that brick pavements laid on about one foot of stone for a base had failed in places, probably because the stone base had not been properly tamped.

Reinforcing Concrete Pavements

The figures for the 460 cities whose reports have been tabulated for this issue show nearly 2,000,000 square yards of concrete pavement built last year, and of this 35 per cent contained reinforcement. By far the largest part of the reinforcement used in the concrete pavements is in the form of fabric rather than bars. A number of engineers reported their intention to use reinforcement in 1921 construction, and all but three of these stated their intention of using fabric, and one of the other three said that bars "probably" would be used.

By far the largest part of the fabric used in these cities weighs between 25 and 35 pounds per 100 square feet of pavement, 28 and 30 pounds appearing to be most popular. About 78 per cent reported use of fabric weighing between 25 and 35 pounds, both inclusive; about 14 per cent reported 40 pounds, the balance being evenly divided among 42, 50 and 100 pounds. In addition, one city reports main members .08 square inch, 6 inches apart. Another reports .058 square inch, spacing not stated. One city uses 32 pounds of fabric in each of two layers, making 64 pounds per 100 square feet.

Alabama's Highway Bonds

On February 16, 1920, the voters of Alabama authorized a bond issue of $25,000,000 for constructing a permanent system of roads in that state. A question having been raised as to the validity of the bonds because of a point of legal procedure in connection therewith, a friendly suit has been started and briefs for and against the validity of the bonds have been prepared for submission to the Supreme Court in order that the point may be authoritatively and finally settled to the satisfaction of all possible purchasers of the bonds.

NEWS OF THE SOCIETIES

Feb. 7—PORTLAND, OREGON SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Feb. 7-8—FLORIDA ENGINEERING SOCIETY. Annual meeting. Lakewood, Fla.

Feb. 8—BOSTON SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Feb. 8—BOSTON SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Feb. 9—THE NEW ENGLAND WATER WORKS ASSOCIATION—February meeting Copley Square Hotel. Boston. Secretary F. H. Gilford, Dedham, Mass.

Feb. 9-12 — AMERICAN ROAD BUILDERS' ASSOCIATION. Eighteenth annual convention, eleventh American Good Roads Congress and twelfth National Good Roads Show, Coliseum, Chicago, Ill.

Feb. 10—SOCIETY OF AUTOMOTIVE ENGINEERS, Hotel New Southern, Columbus, O.

Feb. 11—LOS ANGELES SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Feb. 11-12 — ENGINEERING SOCIETY OF WISCONSIN. Annual meeting. Madison. Secretary, Leonard S. Smith, Madison, Wis.

Feb. 14—AMERICAN ENGINEERING COUNCIL. Technology Club, Syracuse, N. Y. Headquarters at Onandago Hotel.

Feb. 14-16 — NATIONAL CIVIC FEDERATION. 21st annual meeting, Hotel Astor, New York.

Feb. 14-16 — AMERICAN CONCRETE INSTITUTE. Annual meeting. Auditorium Hotel, Chicago, Ill. Secretary, Harvey Whipple, New Telegraph Building, Detroit, Mich.

Feb. 15 — BUFFALO SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Feb. 15—COUNCIL OF THE AMERCAN SOCIETY OF MECHANICAL ENGINEERS. Technology Club, Syracuse, N. Y.

Feb. 15-17 — PROVINCIAL ASSOCIATION OF CONTRACTORS AND SUPPLY DEALERS OF ONTARIO. Startford, Ont.

Feb. 16-18 — AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Seventh midwinter convention. Engineering Societies' Building, New York City.

Feb. 21-23 — MINNESOTA SURVEYORS' AND ENGINEERS' SOCIETY. Annual convention. Hotel Commodore, St. Paul.

Feb. 23—NEW YORK SECTION, AMERICAN SOCIETY OF CIVIL ENGINEERS. Meeting postponed from Feb. 16.

Feb. 25-26—CONSTRUCTION DIVISION, U. S. ARMY. Annual reunion of those identified with this division during the war. Morrison Hotel, Chicago, Ill.

Feb. 28 — PHILADELPHIA SEC- MECHANICAL ENGINEERS. Engineers' Club of Philadelphia.

Feb. 28 — CHICAGO SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

March 11-12 — NORTHWESTERN ASSOCIATION OF GENERAL CONTRACTORS. St. Paul Hotel, St. Paul, Minn.

March 14—AMERICAN ASSOCIATION OF ENGINEERS. The third annual railroad conference. Chicago.

April 27—AMERICAN SOCIETY OF CIVIL ENGINEERS. Annual convention. Houston, Texas.

April 27-29—UNITED STATES CHAMBER OF COMMERCE. 9th annual meeting. Atlantic City, N. J.

May 9-11—AMERICAN ASSOCIATION OF ENGINEERS. 7th annual convention. Buffalo.

May 17-19—NATIONAL FIREMEN'S ASSOCIATION. Twenty-third annual convention. Fort Wayne ,Ind.

June—CONFERENCE OF MAYORS AND OTHER CITY OFFICIALS, State of N. Y. 12th Annual Conference. Elmira, N. Y.

June 6-10—AMERICAN WATER TER WORKS ASSOCIATION. Annual convention at Cleveland, Ohio. Secretary, J. M. Diven, 153 West 71st St., New York.

June 7-9—NATIONAL FIRE PROTECTION ASSOCIATION. Annual meeting. San Francisco, Cal.

Oct., 1921—IOWA SECTION, AMERICAN WATER WORKS ASSOCIATION. Seventh annual meeting.

AMERICAN ENGINEERING COUNCIL

On February 14, the executive board of the American Engineering Council of the Federated American Engineering Societies will hold sessions at Syracuse, N. Y., culminating in the evening in an address by Herbert Hoover, who will outline the new council's plans for dealing with industrial relations and particularly with human waste as it affects the present army of unemployed.

Mr. Hoover will urge co-operation with Congress, with labor organizations, chambers of commerce and other bodies in the campaign planned by the council to remedy economic ills.

On February 15, the national council of the American Society of Mechanical Engineers will convene at the same place. This society has placed its resources and membership of 13,000 behind the movement to federate the country's engineering skill under the headship of Mr. Hoover with the American Engineering Council as the spokesman, who will work "to get America's idle back to work, and keep it at work."

The Syracuse meetings will bring together engineers from every industrial center in the country. Delegations will go from New York, Albany, Utica, Buffalo, Rochester, Schnectady, Troy and other cities. The engineering societies of Chicago, Cleveland, Boston, St. Louis, Pittsburgh, Detroit and other places will be represented by officials of the two councils.

On the board of the American Engineering Council the American Institute of Electrical Engineers is represented by Calvert Townley of New York, vice-president of the Westinghouse Co.; the American Institute of Mining and Metallurgical Engineers by J. Parke Channing of New York; the American Society of Mechanical Engineers by Dean Dexter S. Kimball of Cornell University, and the Associated Engineering Societies of St. Louis by William E. Rolfe. These four, as vice-presidents of the council, are actively assisting Mr. Hoover in framing

As a result of a report submitted to the council by Mr. Hoover, the council will probably encourage the formation of state engineering councils, a process already under way in many states, including Massachusetts and Minnesota. A federation of New York state engineers, it is said, is a probability of the near future.

THE ELEVENTH ANNUAL AMERICAN GOOD ROADS CONGRESS AND SHOW

The eleventh annual American Good Roads Congress and twelfth National Good Roads Show, under the auspices of the American Road Builders' Association, will be held at Coliseum, Chicago, February 8, 9, 10, 11 and 12.

TENTATIVE PROGRAM

February 8, 8 p. m., formal opening of twelfth national Good Roads Show, Coliseum.

February 9, 9 a. m., registration of delegates.

Convention Hall, Coliseum, 10 a. m. —Announcement of convention committees. H. L. Bowlby, Chief War Materials Division, U. S. Bureau of Public Roads, Washington D. C., presiding. "Our National Road Problems," Thomas H. MacDonald, Chief, U. S. Bureau of Public Roads, Washington, D. C. "Relations of the Highway and Motor Transport Movement to Education," Prof. C. J. Tilden, National Director of Highway and Highway Transport Education, Washington, D. C. "Highway Improvements in New England," A. W. Dean, Chief Engineer, Division of Highways, Massachusetts Department of Public Works. "The Local and National Importance of the Lee Highway," Dr. S. M. Johnson, Manager, Lee Highway Association, Roanoke, Va.

Convention Hall, Coliseum, 2 p. m. —George C. Diehl, county engineer, Erie county, N. Y., presiding. "The Highway's Part in the Development of Efficient Transportation," C. W. Reid, Chairman, Transportation Committee, Federal Highway Council, Washington, D. C. Discussion, T. J. Wasser, State Highway Engineer of New Jersey, and others.

Mass Meeting, Medinah Temple, 8 p. m.—Michael J. Faherty, President, American Road Builders' Association, presiding. Musical program. Address of welcome on behalf of the city of Chicago, Hon. William Hale Thompson, mayor of Chicago. Response on behalf of the American Road Builders' Association, by Michael J. Faherty, president. "Good Roads Movies."

Convention Hall, Coliseum, February 10, 10 a. m.—C. M. Upham, Chief Engineer, Delaware State Highway Department, presiding. "Sub-grades," H. G. Shirley, Secretary, Federal Highway Council, Washington, D. C. Discussion, Clifford Older, Chief Highway Engineer of Illinois, and others. "Importance of Drainage in Road Construction," F. H. Eno, Professor of Engineering, Ohio State University. Discussion by H. S. Mattimore, Assistant Engineer, Pennsylvania State Highway Department, and others.

Convention Hall, Coliseum, 2 p. m. —J. A. Duchastel, City Manager, Outremont, Canada, presiding. "Types of Pavements," James H. MacDonald, former State Highway Commissioner of Connecticut, New Haven, Conn. Discussion, Newell D. Darlington, Chairman, California State Highway Commission; Herbert Nunn, State Highway Engineer of Oregon, and others. "Highway Researches and What the Results Indicate," A. T. Goldbeck, Chief, Division of Tests, U.

S. Bureau of Public Roads, Washington, D. C. Discussion, Anson W. Marston, Dean, Iowa State College, and others.

Evening Entertainment — Dinner-dance at the Congress Hotel.

Convention Hall, February 11, 10 a. m.—Frank F. Rogers, State Highway Commissioner of Michigan, presiding. "Recent Developments in Road Building," Edward N. Hines, Chairman of Board, County Commissioners, Wayne County, Mich. Discussion, W. D. Uhler, Chief Engineer, Pennsylvania State Highway Department; R. Keith Compton. Chairman, Baltimore Paving Commission, and others.

Convention Hall, Coliseum, 2 p. m. —Howard F. Beebe, President, Harris, Forbes & Co., New York City, presiding. "Highway Finance," H. C. Sylvester, Vice-President, National City Co., New York City. Discussion, S. E. Bradt, Superintendent of Highways, Department of Public Works and Buildings, Springfield, Ill.; H. P. Gillette, Editor, *Engineering and Contracting*, and others.

Evening Entertainment — Theater party at two of Chicago's leading theaters.

Convention Hall, Coliseum, February 12, 10 a. m.—Walter A. Rogers, of Bates & Rogers, Chicago Ill., President, Associated General Contractors, presiding. "Relation Between Engineers and Contractors," W. A. Rogers, President, Associated General Contractors. Discussion, R. G. Collins, Keystone Construction Co.; A. R. Hirst, State Highway Engineer of Wisconsin; D. A. Garber, President, Northeastern Construction Co., New York City, and others.

Convention Hall, Coliseum, 2 p. m.—Question box, report of resolutions committee, election of nominating committee.

As many women will be present, special entertainment features have been provided for their benefit, including a reception and tea, February 9, at the Congress Hotel; a sightseeing tour by automobile, followed by a luncheon and entertainment at the Drake Hotel; a shopping tour; a luncheon at the South Shore Country Club, and dinner and dance at the Congress Hotel.

THE NEW ENGLAND WATER WORKS ASSOCIATION

The annual meeting of the New England Water Works Association was held on January 12 at the Copley Square Hotel, Boston, Mass. The executive committee met in the morning at the association headquarters, the Tremont Temple, and luncheon was served later in the hotel.

The following officers were elected for the ensuing year: President, Charles W. Sherman; vice-presidents, Frank A. Barbour, Percy R. Sanders, William W. Brush, Reeves J. Newsom, Patrick Gear and George A. Carpenter; additional members of the executive committee: David A. Heffernan, James A. Newlands and Arthur A. Blackmer; secretary, Frank J. Guffird; treasurer, Lewis M. Bancroft; editor and advertising agent, Henry A. Symonds; and finance committee, George H. Finneran, A. R. Hathaway and Frank A. Marston.

A report was then read by the retiring president, Henry V. Macksey, which showed the association to be in sound financial condition and advancing along progressive lines. Secretary Frank J. Gifford reported the present membership as numbering 872 persons, consisting of 14 honorary members, 788 active members and 70 associate members. This was followed by a short speech by the new president, prophesying a prosperous year for 1921.

AMERICAN CONCRETE INSTITUTE

A session on contractor's plant, February 15, 8 p. m., will receive the report of the special committee on contractor's plant in reinforced concrete building construction. A survey of the concrete road building situation indicates that while many contracts were not completed last year, leaving a balance of incompleted contracts of 33,000,000 square yards, 1920 was the biggest year in actual yardage put down that we have had and 1921 will probably eclipse that record. An address by F. M. Ballsley of the Wisconsin State Highway Department on Equipment for Concrete Road Construction has been prepared after a survey of many jobs in several states.

A paper by C. R. Ege is on Developments in Construction Plant and Crew Organization in Concrete Road Work.

A. C. Irwin will present a compilation of small bridge and culvert standards as used at this time in many cities.

A meeting of the Committee on Concrete Roads, Clifford Older, chairman, will probably be held during the convention.

Concrete products manufacturers will have a special session February 16, at 2 p. m., and will present the revised standards for building units.

J. W. Lowell, of the Universal Portland Cement Co., will present a paper on Coloring Concrete.

J. C. Pearson, chairman of the Committee on Concrete Surfaces, will present a report outlining important work to be undertaken by that committee.

Mr. Pearson will also present a paper on the Shrinkage of Portland Cement Mortars, with Special Reference to Stucco.

The changing situation with regard to lumber supply for form work has prompted President Turner with the authorization of the Board of Direction to appoint a special committee on Steel Forms.

The Committee on Reinforced Concrete Chimneys, J. G. Mingle, chairman, proposed to submit a set of standards for the design and construction of reinforced concrete chimneys. "Our idea will be to make up the specifications in such a manner that they will be of use to the average man and the architect and engineer rather than try to get the different chimney companies to adopt the same proposal form. It will be short and concise to set forth the best practice in design and construction."

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

On February 2, the Ontario section of the A. S. M. E. held a joint meeting with the annual meeting of the Engineering Institute of Canada at the King Edward Hotel, Toronto, Canada. Topics discussed were the "Effects of Corrosion on Steel Pipe, and the Manufacture of Very Large Steel Pipes up to 96 Inches," by F. N. Speller, of the National Tube Co., and "Aeroplane Wing Tips," and "Wind Channel Intakes," both by J. H. Parkin, Jr.

At the meeting of the Boston section to be held on February 8, the following papers will be read: "Water Power Development and the Stand-by Steam Stations as Applied to the General Subject of Power Development in England" and "Recent Water Wheel Developments and Settlings," by W. M. White, chief engineer, hydraulic department, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

On February 16, at the meeting of the Buffalo section, "Modern Practice in Arc Welding" will be discussed by A. M. Candy, of the Westinghouse Electric & Manufacturing Co.

NEW ENGLAND WATER WORKS ASSOCIATION

The February meeting of this association will be held at Copley Square Hotel, Boston, February 9.

Program—11 a. m., meeting of the executive committee at the headquarters, Tremont Temple. 1 p. m., lunch will be served at Copley Square Hotel, tickets $1.50. 2 p. m., papers, "The Need of Uniformity in Plumbing Regulations," by George C. Whipple, Professor of Sanitary Engineering, Harvard Engineering School. "Relations Between Plumbers and Water Works Superintendents," by G. Wilbur Thompson, president of the Massachusetts Association of Master Plumbers. "The Hydraulics of the Flush Valve," by Gordon M. Fair, Instructor in Sanitary Engineering, Harvard Engineering School. Professor Whipple will discuss the bill which has just been introduced into the legislature by the State Department of Health. This bill contains matter of great importance to the members.

KENTUCKY HIGHWAY CONTRACTORS' ASSOCIATION

At a recent meeting of the Kentucky Contractors' Association the following officers were elected: President, George N. Eady; first vice-president, Henry Bickel; and second vice-president, George Carey.

MEMPHIS ENGINEERS' CLUB

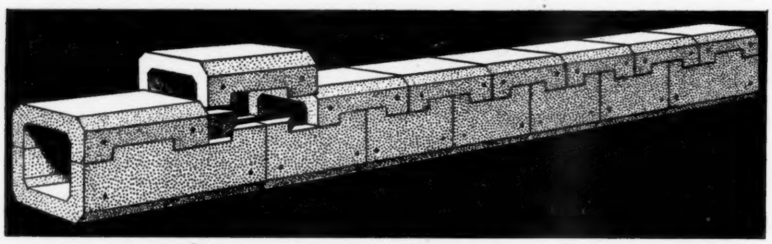
At a dinner held on January 10, the Memphis Engineers' Club elected the following officers for next year: President, Robert W. Gay; vice-president, J. H. Haylow; and secretary-treasurer, A. S. Fry.

LARGE VOTE FOR A. S. C. E. OFFICERS

An interesting feature of the meeting of the American Society of Civil Engineers held in New York on January 19 was the size of the vote for officers. 80 per cent of the corporate membership was represented in the vote, 7,008 ballots being cast. And when it is considered that about 500 members live outside of the United States or Canada and that only a small number of these voted, it can be assumed that the percentage of eligible voters in the United States and Canada who did cast votes was about 85.

New Appliances

Describing New Machinery, Apparatus, Materials and Methods and Recent Interesting Installations



DUPLICATE UNITS OF INTERLOCKING CONCRETE CULVERT ASSEMBLED

INTERLOCKING WENDELKEN CONCRETE CULVERT

The Wendelken interlocking concrete culvert is assembled from a series of interlocking, plant-made concrete units, reinforced to withstand, without overcovering, the load imposed by a 17-ton roller, the load on any unit being distributed over a ground surface double the length of the unit.

Top and bottom units are exactly the same and interchangeable. In order to clean the culvert, the top units can be removed by means of pins or hooks inserted in holes cast in each top unit for that purpose, the culvert cleaned and the top units replaced.

The dimensions can be such as to provide the size and shape of openings necessary to meet any requirements of the relation of flow line to road surface and required discharge capacity. The smooth interior provides the minimum of frictional resistance and therefore a large discharge capacity in proportion to the area of the opening. It can be quickly installed at any time of the year and can be removed, if necessary, to another location. The design is technically correct, and the specifications conform to the recommendations of the Joint Committee on Concrete and Reinforced Concrete.

With blocks of three standard sizes having inside clear heights of 5 inches, 7 inches and 11 inches, six different sizes of culverts with clear openings of 10 x 24 inches to 22 x 24 inches can be constructed. Each unit is reinforced on all three sides by a framework of bent steel bars. The units are made in class "A" designed to carry a 17-ton roller without earth covering over the conduit and class "B" is designed to carry the same roller when the culvert is covered with 1 foot or more of earth. The width of the units are 15, 18, 24 and 30 inches and the thickness of the top and bottom flanges varies from 2½ to 4 inches while their capacity for discharge in second-feet varies from 1.66 to 20.50, while the corresponding sizes of corrugated iron pipe capacities vary from 1.13 to 7.80.

This interlocking culvert company furnishes steel inside and outside forms for manufacture by contractors and others of the culvert units, with which it is estimated they can be made for 50 per cent of the average selling prices.

These culverts have been in successful satisfactory service in Denver for two years and the United States government has recently secured the right to manufacture them for use on thirty-five reclamation projects.

INDUSTRIAL NOTES

After February 1, the new warehouse plant of the National Cast Iron Pipe Co., at 37th street and South Ashland avenue, Chicago, Ill., is expected to be in operation. A complete line of 3-inch to 24-inch cast iron pipe and specials, as well as valve and roadway boxes, will be carried at this warehouse.

Howard H. Marsh, formerly district manager of *Railway Age*, has become president of the Victory Equipment Co., with headquarters at 444 Maison Blanche Annex, New Orleans, La., where he will handle the following accounts: McMyler Interstate Co., Cleveland locomotive cranes, pile drivers and material handling equipment; Ball Engineer Co., Erie, Pa., steam shovels and railroad ditchers; Schaefer Equipment Co., Pittsburgh, Pa., truck lever connection, brake levers, brake rod jaws and stake pockets; and Equipment Manufacturing Co., Cleveland, Ohio, trucks and trailers.

Wallace & Tiernan Co., Inc., has opened a new plant at Newark, N. J., where all its business will be conducted, including all branches of engineering, manufacturing, sales and executive work.

ADAMSON NOW MAKES TANKS, AND ARC WELDED PRODUCTS

The Adamson Manufacturing Co., East Palestine, Ohio, has added a new department for manufacturing all kinds of storage, pneumatic and pressure tanks, welded pipe, battery casings, evaporators, condensors and a large line of arc-welded products.

One of the two big plants of the Macomb Sewer Pipe Co., at Macomb, Ill., has closed down. This move was the result of a lack of orders. All of the Macomb clay industries with the exception of two plants have shut down now.

The Great Western Contracting Co., Kansas City, Mo., has changed its name to the Rawlings Industrial Equipment Co. This organization acts as sales engineers for the manufacturers of power plant machinery. Besides handling coal and ash conveyors for the Conveyors Corporation of America, Chicago, Ill., this company represents the Springfield Boiler Co. and the Cooling Tower Co.

NATIONAL STEEL FABRIC COMPANY

Announcement is made of the opening of an Atlanta, Ga., office by the National Steel Fabric Co., in charge of H. S. Gibboney, district manager, 604 Walton building.

THE AUSTIN MACHINERY COMPANY'S EXHIBIT

At the Good Roads Show and National Good Roads Congress and Convention, Chicago, Feb. 9-12, there will be included in the Austin Machinery Corporation's seventy-two-ton display in the first section of the main exhibition area, their mammoth 28E Cube-Hex paver of one cubic yard capacity (the largest all-multipedal paver in the world), road builders' crane and dragline, gasoline locomotive, industrial cars and batch boxes, trenching machine, backfiller and building mixers. Moving pictures will be run continuously.

HIGHWAY TRANSPORTATION SHOW

At the Highway Transportation Show that was held on January 3-8 by the Motor Truck Association of America in the armories at 62d street and Columbus avenue and 68th street and Broadway, New York, liberal use was made of moving pictures to show highway transportation as compared with railroads and waterways, including the film, "What's Your Hurry," featuring Wallace Reid, and the "Neck of the Bottle," which shows all forms of transportation in New York City, where there are more than 71,000 motor trucks, some of them performing extraordinary and little-known service.

Good roads films well illustrated the design and advantages of good roads, and the causes of wear, including a special slow-moving film demonstrating the effect of high speed on tires, springs, body and load of a truck traveling on a rough surface. Another film presented an animated diagram of the operation of the lubrication system and indicated the necessary repairs and maintenance.

LARGE SALES OF HIGHWAY SNOW PLOWERS

The Good Roads Machinery Co., Inc., has recently sold twenty Champion snow plows to the Maryland State Highway Department, fifty-two Champion snow plows to the New Jersey State Highway Department, sixty Champion snow plows to the Massachusetts State Highway Department and three hundred Champion snow plows to the city of New York.

The Austin Machinery Corporation has established an office at 721 Andrus building, Minneapolis, Minn., with George A. Ralph in charge.